How True North Was Measured by the Pole star in Ancient China

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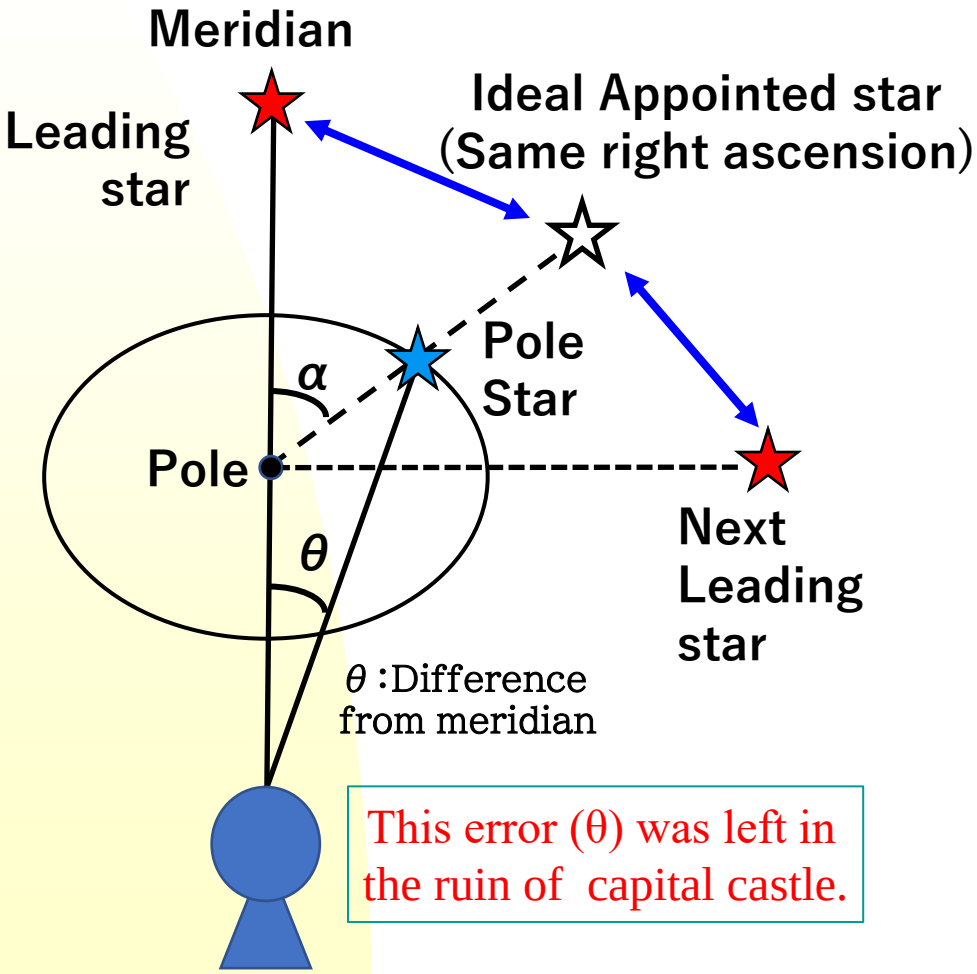

This error (θ) was left in the ruin of capital castle.

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December 24, 2022 , 1st ver.

How True North Was Measured by the Pole star in Ancient China

- Maps used in presentation are from Google Earth Pro.
- The author has used Google Earth Pro to measure latitude and longitude of ruins and calculate direction..

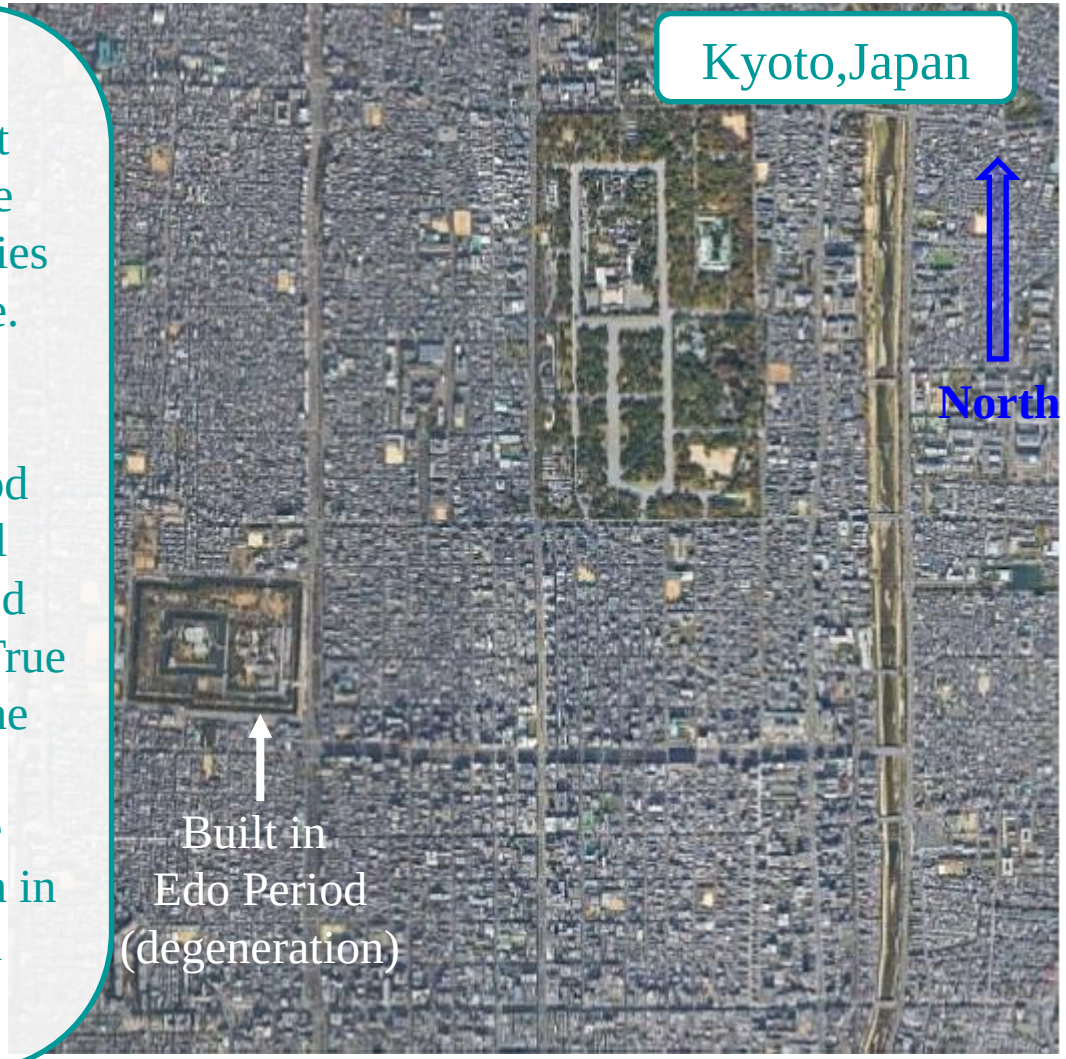
1. The discovery of the True north measurement method by the Pole Star.

Thoughts behind Kyoto's beautiful streetscape

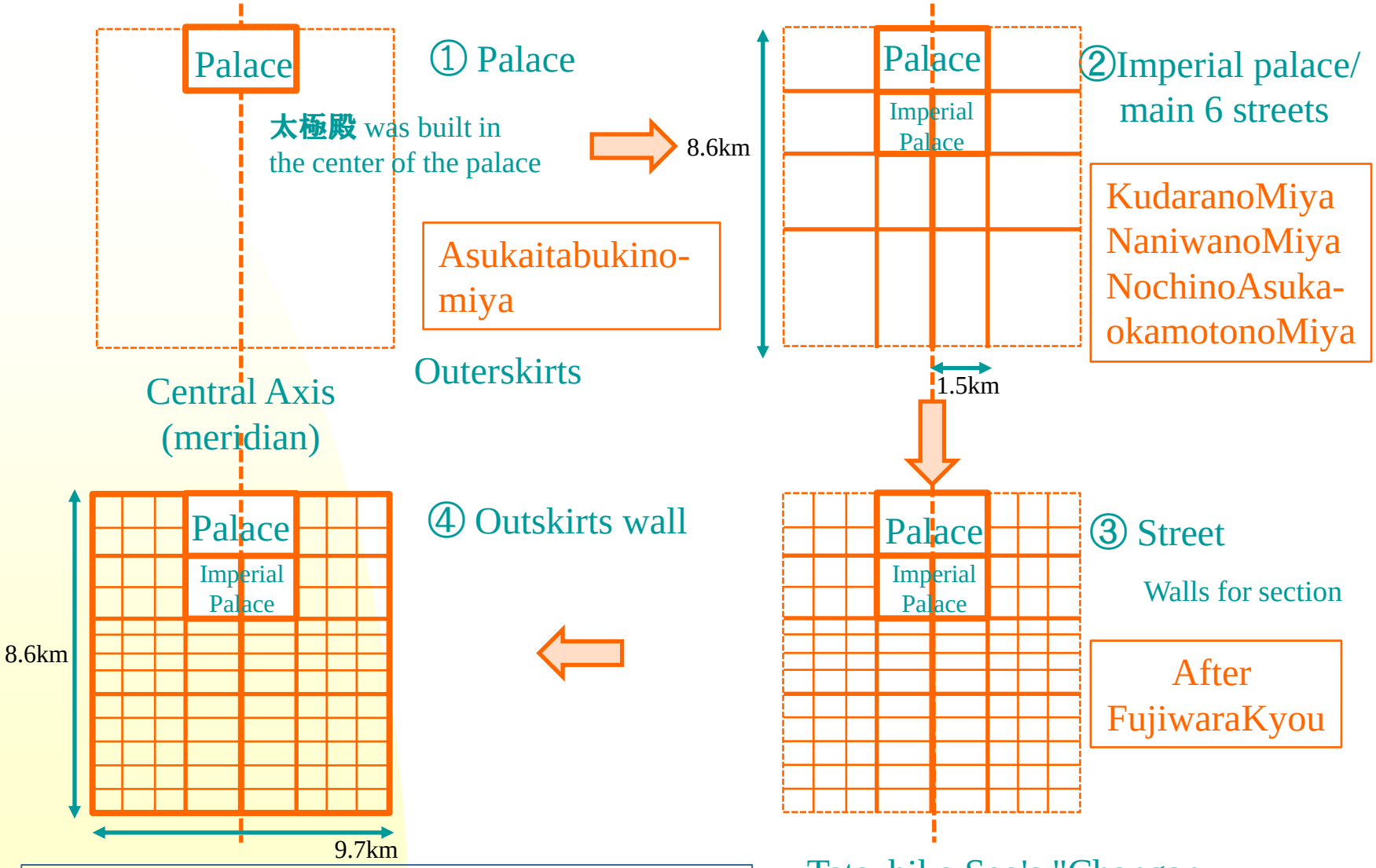
Kyoto's north-south streetscape is based on Jobo（Block） in the Heian period.

Tatsuhiko Seo's "Changan City Plan"(2001)p.158 says，"the ancient capital of China, was built as a stage for dynastic ceremonies and embodies the existence of a heavenly mandate. By doing so, the emperors on earth tried to prove their legitimacy."

- The True north measuring method for the stage of the dynasty ritual that embodied the Hokushin (God of pole) ruling thought was the True north measuring method using the Pole Star.
- This idea and the style of palace palaces were introduced to Japan in the Asuka(7c) period and carried over to Heian period.



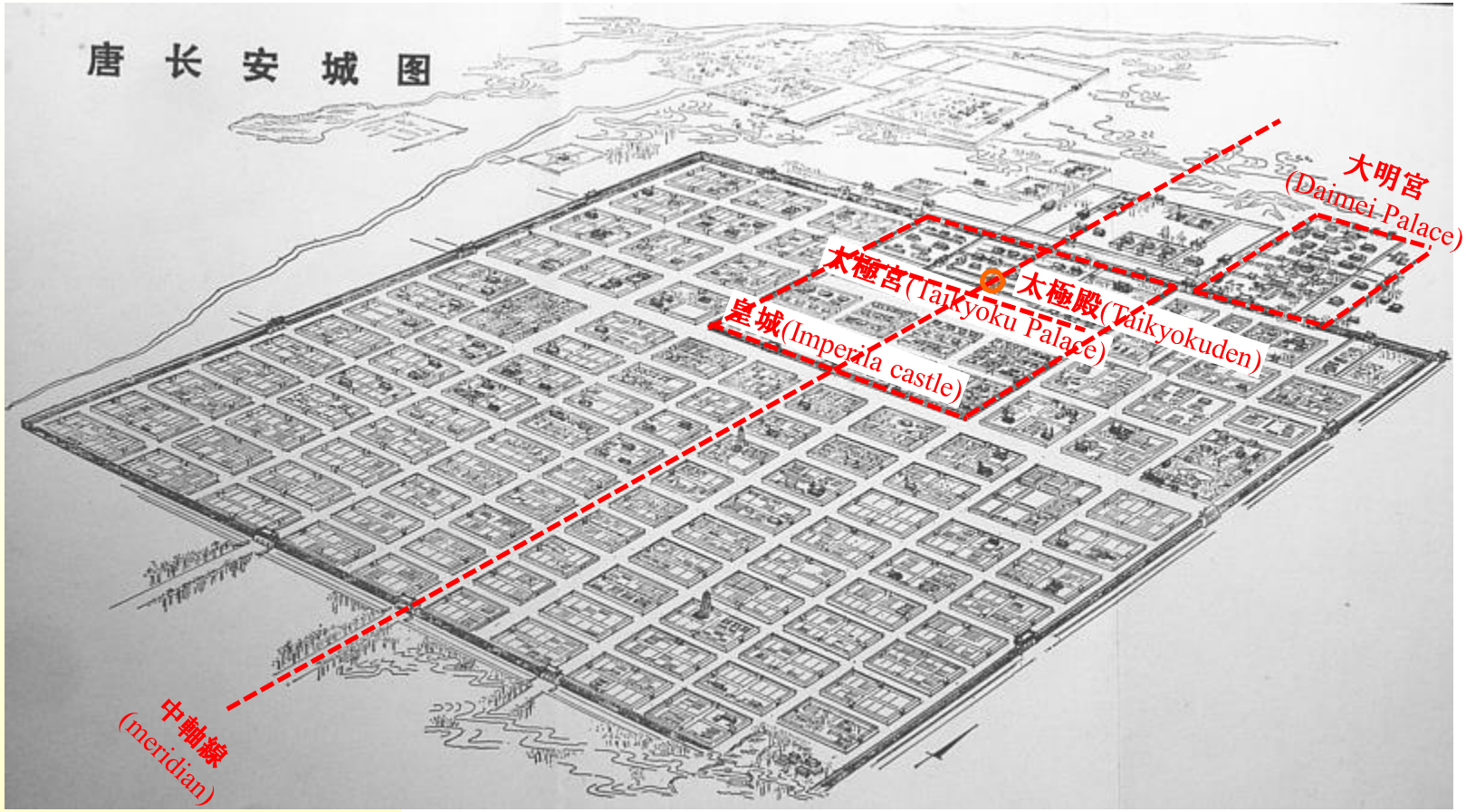
The construction process of Chang'an Castle



Tatsuhiko Seo's "Changan City Plan"(2001)p.121

It is believed that this knowledge was brought to Japan by students for Sui returned in 632.

Reconstruction drawing of Chang'an Castle.

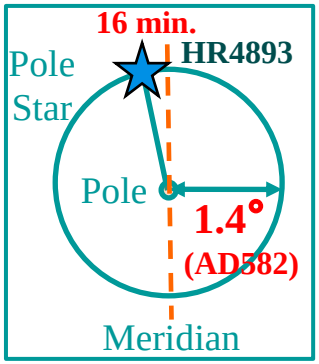


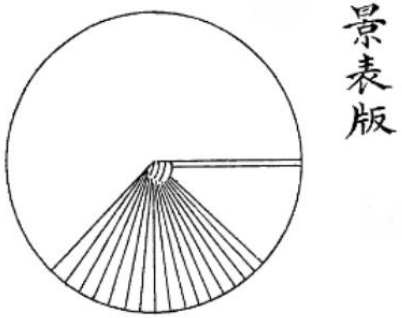
【「中国都城歴史図録 第二集」(1986)p.148-149より】

How did they put the central axis of the capital on the meridian?

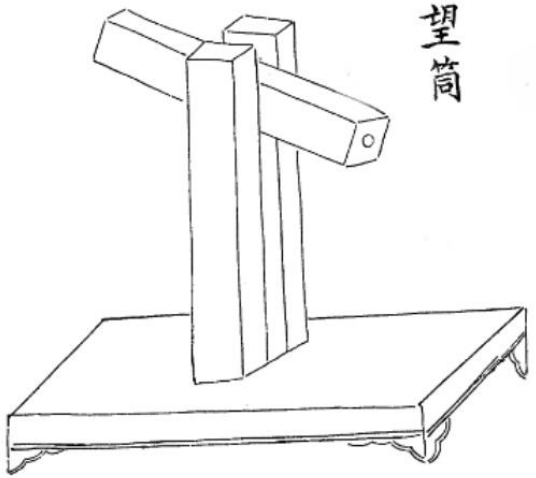
- **妹尾達彦著『長安の都市計画』**(2001)p.118
  (Tatsuhiko Seo's "Changan City Plan")
  The direction is measured by Pole star
  - the True north measurement method using the sun and the Pole Star called "**取正之制**" (zhèngzhī zhì) in **『営造法式』**(1103, Yíngzào fàshì) But timing of the measurement is not mentioned.
  - the direction of Chang'an Castle was 16 minutes west from true north. (1 degree is 60 minutes.)
- **北条芳隆著「古墳の方位と太陽」**(2017)p.86,
  (Yoshitaka Hojyo's "Directio of ancient tomb and sun")
  - and if he pays attention to the time of the Pole Star, he should have been able to increase the accuracy to around ±0.1° .

The problem : How they know the time when the Pole Star was near the meridian without clock?





① Check the mridian by sun



②In the night, measure the direction by Pole star.

"**取正之制**" in "**営造法式**"
『石印宋李明仲営造法式』
東北大学附属図書館蔵

Documents that can assume the time of the measurement

『詩(経)』(Shijing)

『詩(経)。定之方中(，作于楚宮)。又揆之以日(，作于楚室)。
注云。定，營室也。方中，昏正四方也。揆，度也。度日出日入，以知東西。南視定，北準極(星)，以正南北。』 (from**『営造法式』**)

Translation：According to the Book of Poetry, when the fixed star is in the middle of the south (the temple is built on the hills of Chu). Measure the shadow of the sun and determine the direction (build a palace on the hill of Chu). According to the notes ("**毛享傳**"), the fixed (star) is the Shi xiu("**室**"). Hochu(**方中**) is to set the four directions correctly at dusk. Revolt(**揆**) is to measure. Measure the sunrise and sunset and know the direction of east and west. Look at the southern fixed star and determine the north-south direction correctly based on the north pole (star). (This poem is related to the fact that Duke Huan(**桓公**) of Qi(**斉**) helped Duke Wen(**文公**)of Wei(**衛**) to build a capital castle in Chuqiu (**楚丘**,to the east of present-day Hui County, Henan Province) in the first month of the 2nd year of **僖公**, year BC658.)

『晏子春秋』(Yanzi Chunqiu)

『古之立国者，南望南斗，北戴樞星，彼安有朝夕哉』

(**『営造法式』には記載なし**)

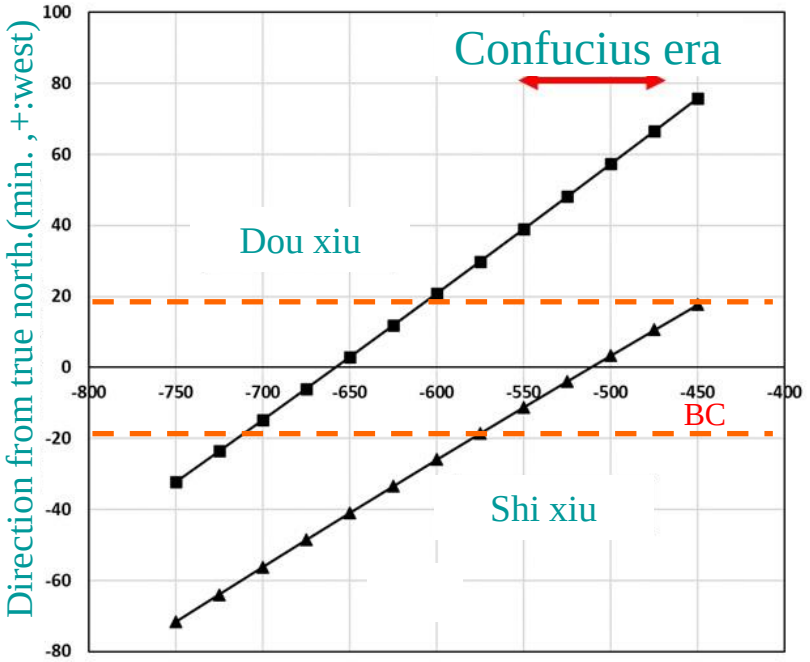
Translation: One who establishes a country in ancient times, observes for Dou xiu(**南斗**) in the south, receives a Pole star in the north, and settles (corrects) the east and west.

There are descriptions of 28 leading stars which are not related to Pole star observations.

Direction of Pole star at the Chunqiu era (Pole star : HR4927)

- The direction from true north when looking at the Pole Star when the leading stars of Dou xiu and Shi are at the meridian.
- The direction is about ±20 minutes from true north within Chunqiu era.
- From the Chunqiu era at the latest, the Pole Star was used to measure the direction of capital castle.

HR is number of the Bright Star Catalog.



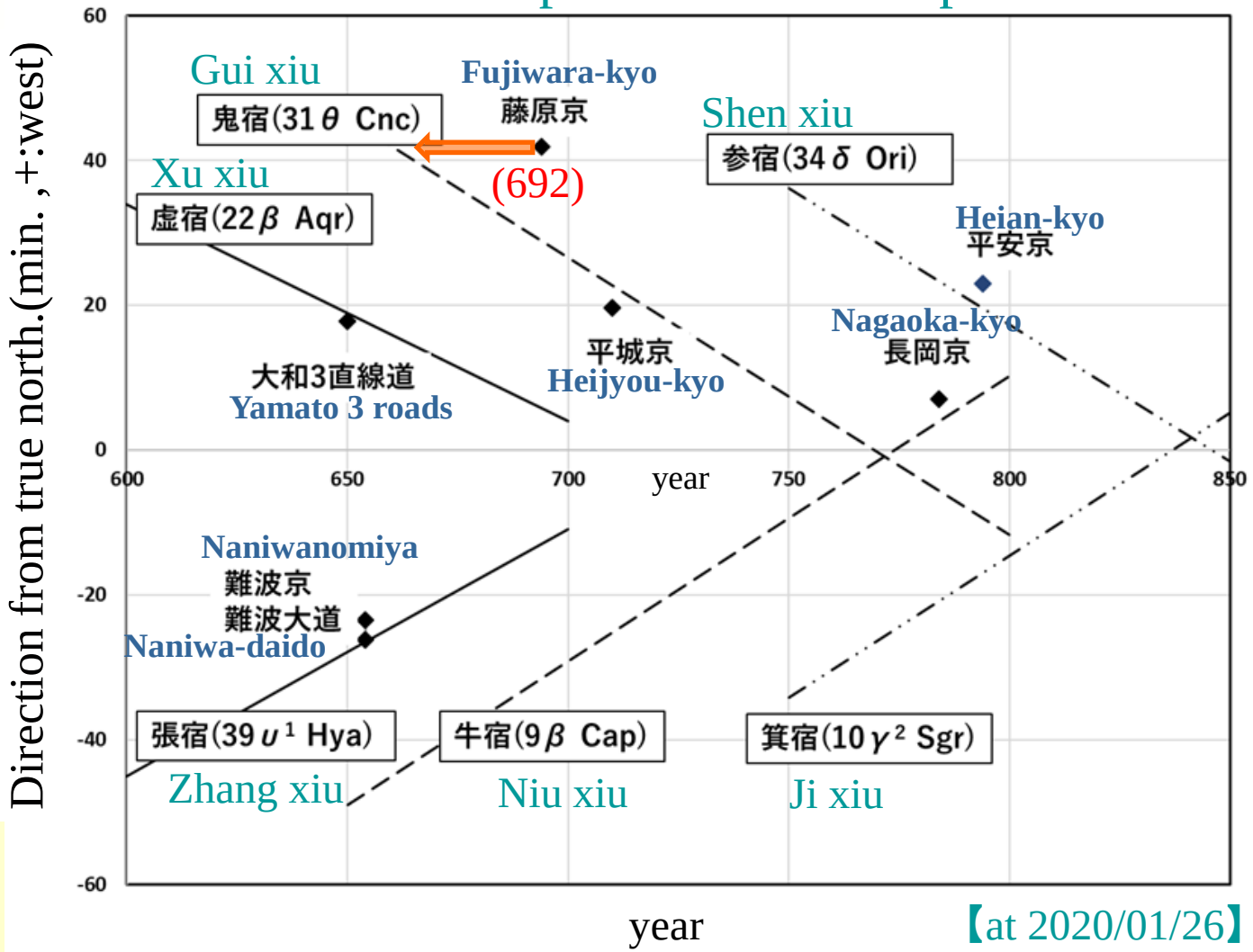
	Pole(HR4927)		Dou xiu (ϕ Sgr,HR7039)				Shi xiu (α Peg,HR8781)			
Year	RA. $\alpha 0$	Dec. $\delta 0$	RA. $\alpha 1$	Dec. $\delta 1$	$\alpha 0-\alpha 1$	Direc. (min.)	RA. $\alpha 2$	Dec. $\delta 2$	$\alpha 0-\alpha 2$	Direc (min.
-750	32.3	89.0	239.0	-24.4	−206.7	−32.3	312.2	2.2	−279.9	−71.7
-700	44.4	89.2	239.8	-24.5	−195.4	−14.8	312.8	2.4	−268.5	−56.2
-650	64.3	89.4	240.5	-24.7	−176.2	2.9	313.5	2.6	−249.1	−41.0
-600	93.1	89.5	241.2	-24.8	−148.2	20.9	314.1	2.8	−221.0	−26.0
-550	120.5	89.4	242.0	-24.9	−121.5	39.0	314.7	3.0	−194.2	−11.2
-500	138.6	89.2	242.7	-25.1	−104.1	57.3	315.3	3.2	−176.7	3.4
-450	149.6	89.0	243.5	-25.2	−93.9	75.9	315.9	3.4	−166.4	17.8

True north whin Dou xiu is at the meridian. ⇨ -650

True north whin Shi xiu is at the meridian. ⇨ -500

Azimuth line by Pole star(HR4893) with leading stars and direction of the ruins of Capital castle

The method of measuring directions using the Pole Star was introduced to Japan in the Asuka period.



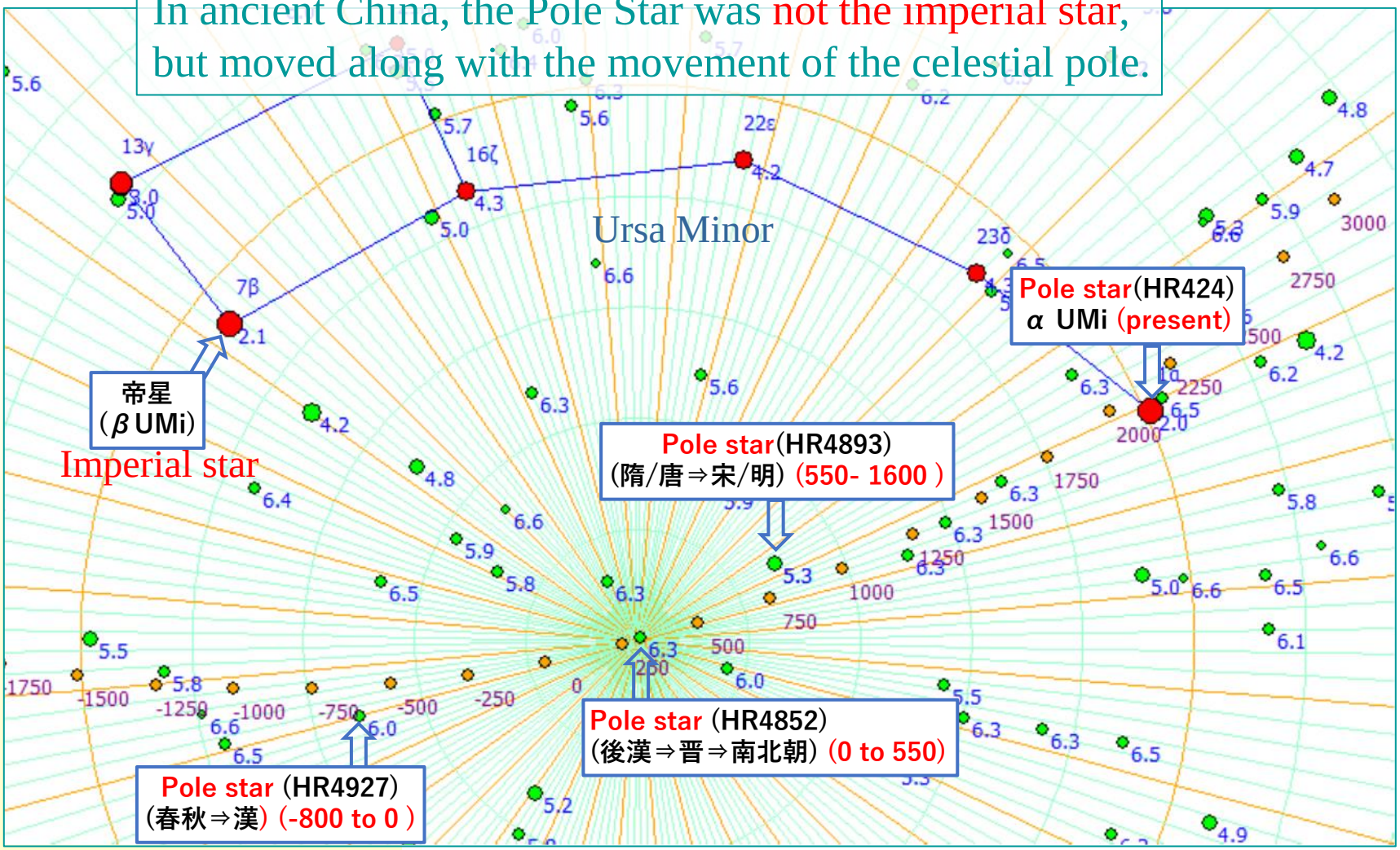
year

【at 2020/01/26】

2. Identification of the ancient Pole Star for the True north measurement

The Pole Star from the Chunqiu era to the present

In ancient China, the Pole Star was not the imperial star, but moved along with the movement of the celestial pole.



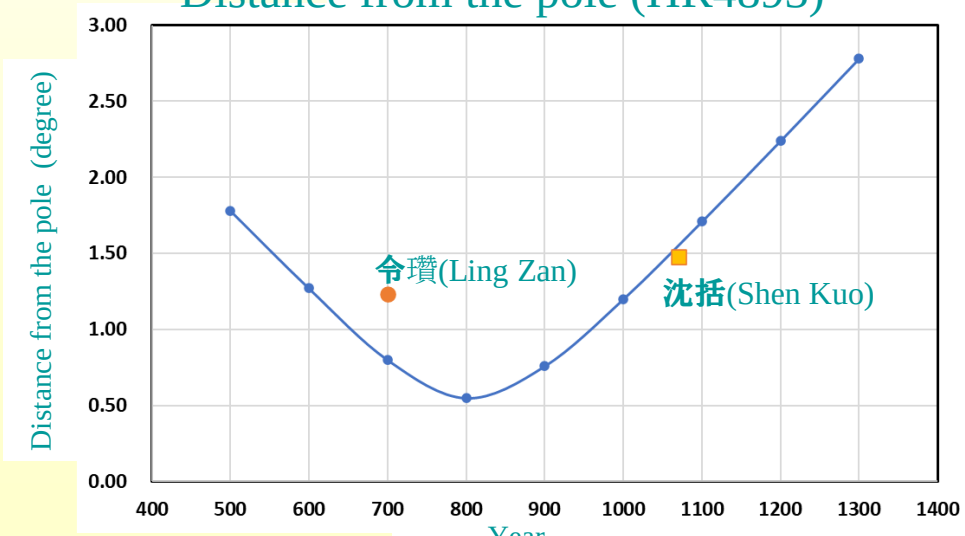
Note: Star charts in the chart are stars up to 6.6 magnitude according to "SKY2000 Master Catalog, Version 5" (2006).A star map in 300 AD. The numbers are the grades of light. The small yellow circle is the position of the celestial pole. The declination scale interval is 2° .

Identification of Pole star (HR4893) from Sui-Tang to Song-Yuan-Ming Dynast

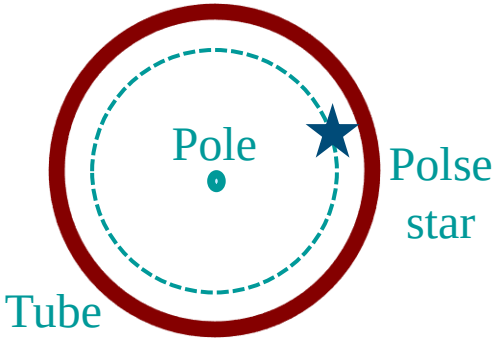
『其五，前世皆以極星爲天中，自祖暅以璣衡窺考天極不動處，乃在極星之末猶一度有餘。今銅儀天樞内徑一度有半，乃謬以衡端之度爲率。若璣衡端平，則極星常游天樞之外；璣衡小偏，則極星乍出乍入。令瓚舊法，天樞乃徑二度有半，蓋欲使極星游於樞中也。臣考驗極星更三月，而後知天中不動處遠極星乃三度有餘(天樞徑)，則祖暅窺考猶爲未審。今當爲天樞徑七度(誤解)，使人目切南樞望之，星正循北極【。】樞裏周常見不隱，天體方正。』宋史天文志[彙編・第三冊] p.804

- Ling Zan (令瓚,early 700s) moved the Pole star in the viewing tube of the armillary sphere and measured 2.5 degrees (radius 1.25 degrees) between the celestial pole and the Pole star.
- A government official (Song Dynasty: Shen Kuo 沈括) tested the Pole star for three months, and found that the fixed point of the center of the sky was more than 3 degrees (wrong, diameter) from the Pole star. He found the radius to be about 1.5 degrees.

Distance from the pole (HR4893)



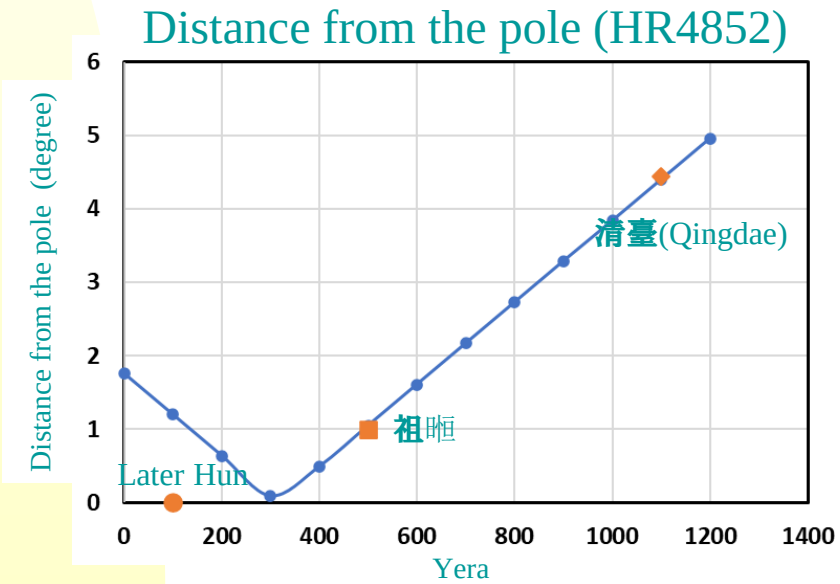
Moving the pole star in the viewing tube of the armillary sphere。



Identification of the Pole Star(HR4852) from the Later Han to the Northern and Southern Dynasties(6 c)

『北極五星在紫微宮中，北辰最尊者也，其紐星爲天樞，天運無窮，三光迭耀，而極星不移，故曰「居其所而衆星共之」。樞星在天心，四方去極各九十一度。賈逵、張衡、蔡邕、王蕃、陸績皆以北極紐星之樞，是不動處。在紐星末猶一度有餘。今清臺則去極四度半。』宋史天文志[彙編･第三冊] p.820

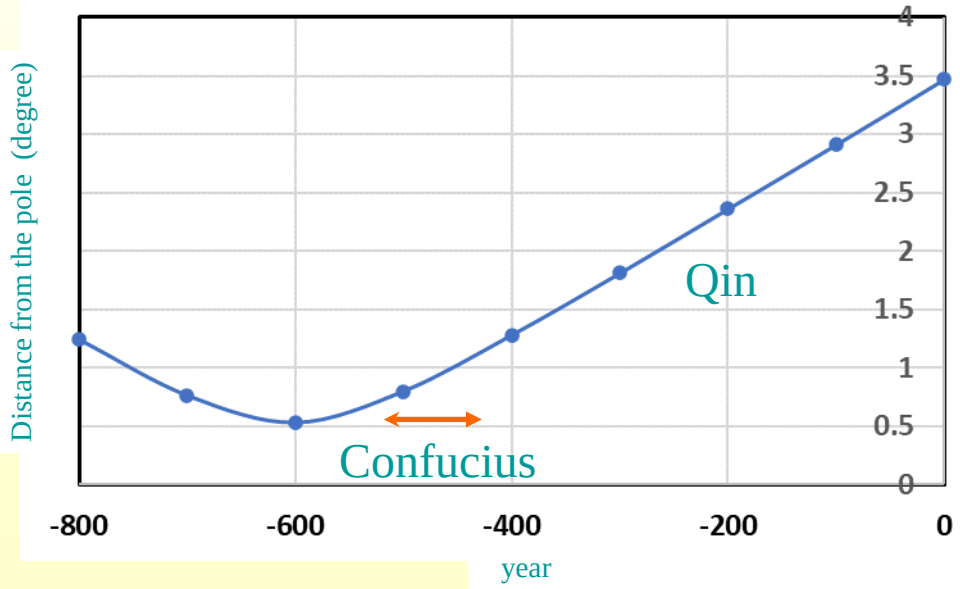
- **賈逵**(30-101)、**張衡**(78-139)、**蔡**邕(132-192)、**王蕃**(228-266)、**陸績**(188-219): Everyone thought that the Pole star was the pivot of the heavens and did not move.
- It was said that the pole star was still more than 1° from the place of immovable by the **祖**暅(Zǔ gèng) (person around 500).
- Now (Song dynasty) when Qingdae**清臺** measured it, it was 4.5 degrees.



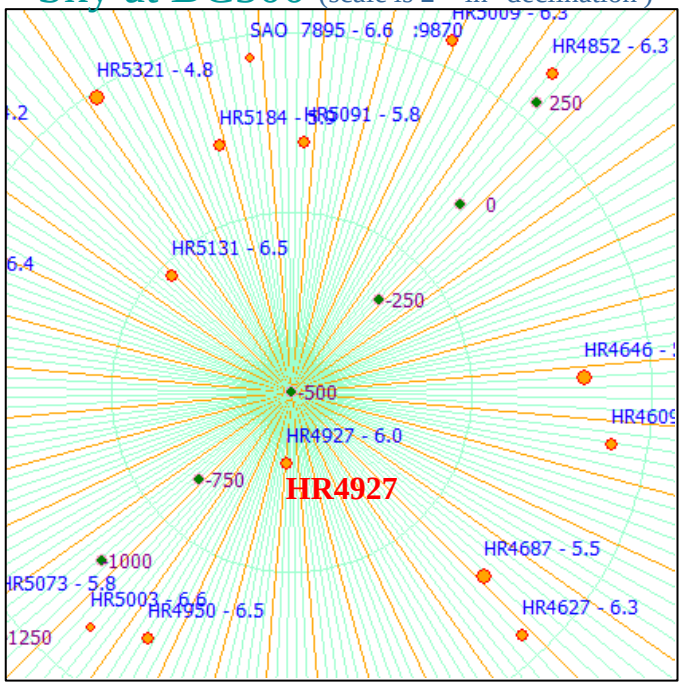
Identification of the Pole Star(HR4927) from Chunqiu to Fomer Han Dynasties

- Confucius's Analects「北辰居其所而衆星共之」(The Hokushin is in place and the other stars are with it.)。
  ⇒At the time of Confucius, it seemed immovable because it was within 1 degree from the Pole.
- Lüshi Chunqiu in Qin「極星與天俱游，而天極不移」(The Pole star moves with the sky, the North Pole does not move)
  ⇒It was about 2 degrees in the Qin Dynasty, so it appeared to move.

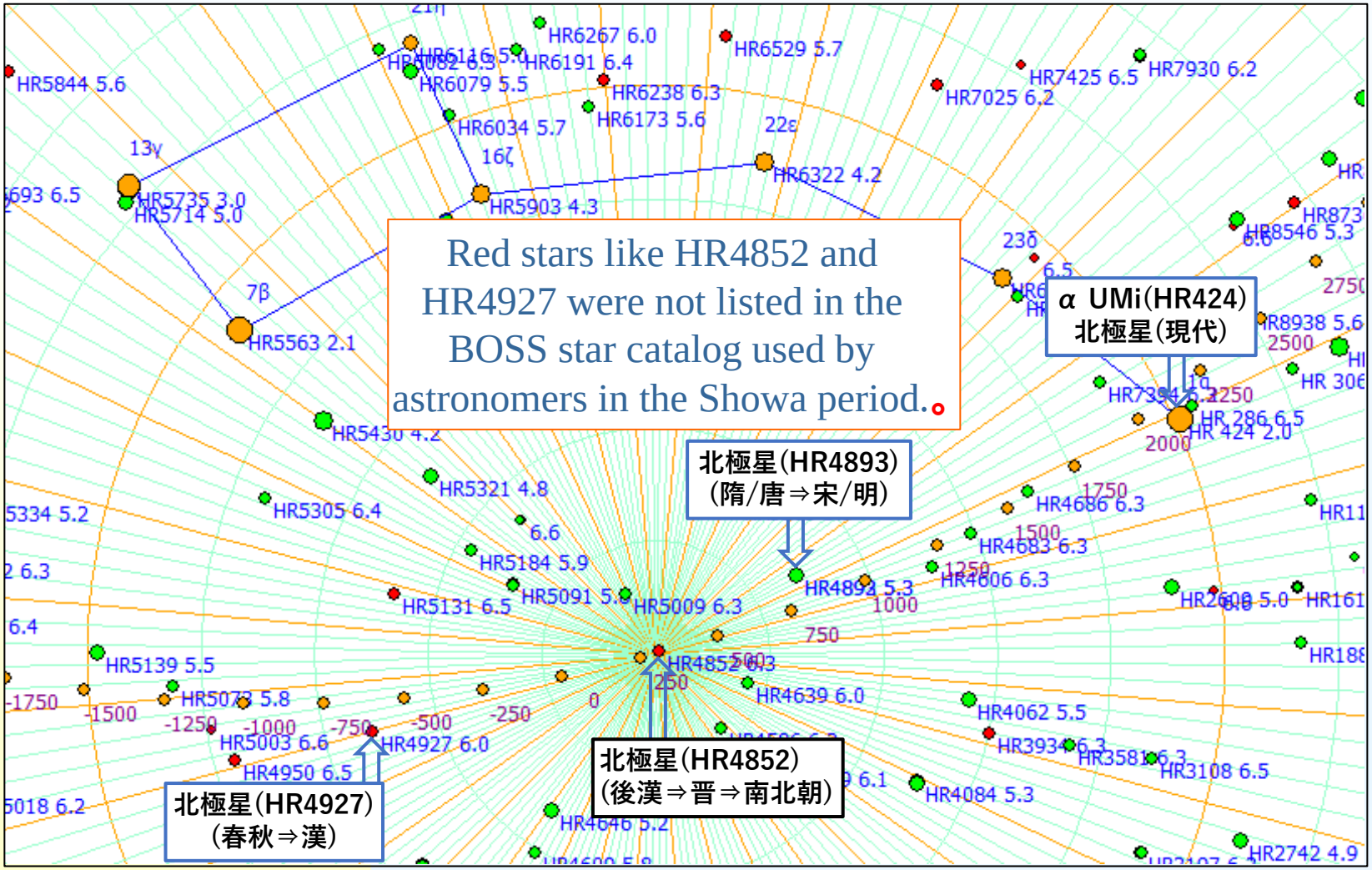
Distance from the pole (HR4927)



Sky at BC500 (scale is 2° in declination)



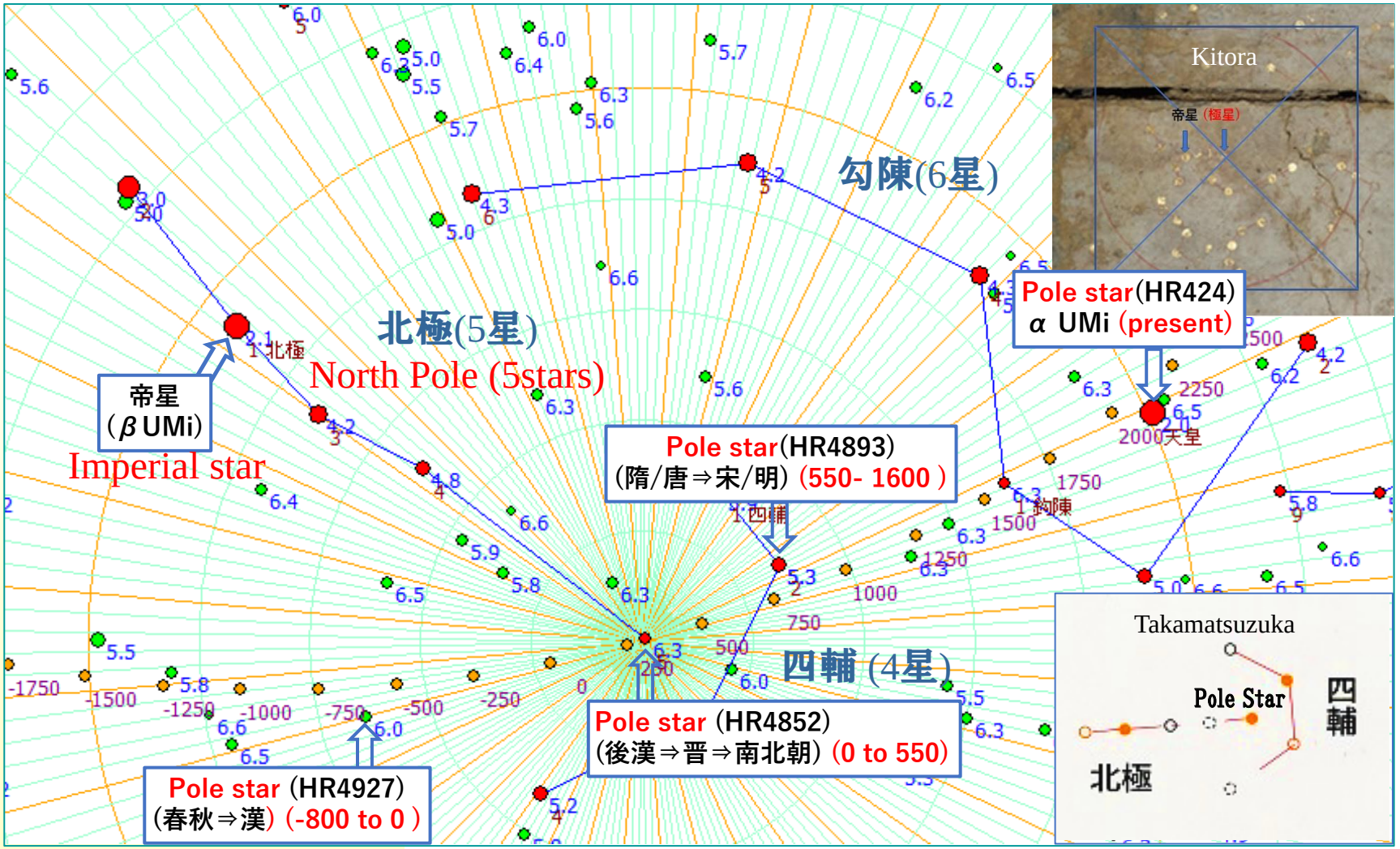
Why the Ancient Pole Star Wasn't Identified ?



Note : Sky at AD300.

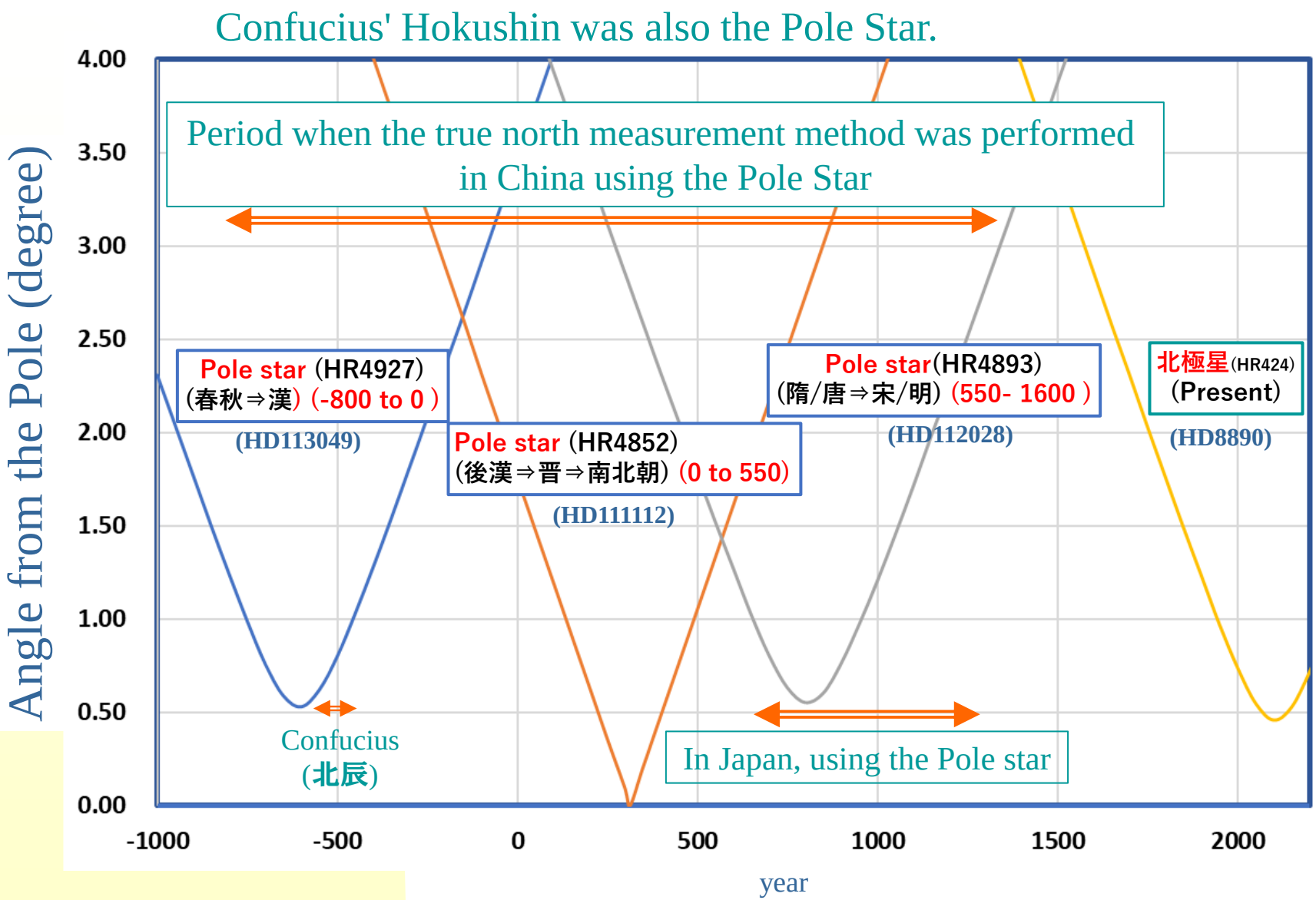
Movement of Pole star from Chunqiu to present

Chinese constellations based on the identification of the original map of the Jin dynasty (created in early Tang Dynasty).



Note: Position at AD300年。 Kitora Astronomical Map is from「キトラ古墳天文図　写真資料集」(2016) PL.5. Takamatsuuzuka star map is from 飛鳥歴史公園HP.

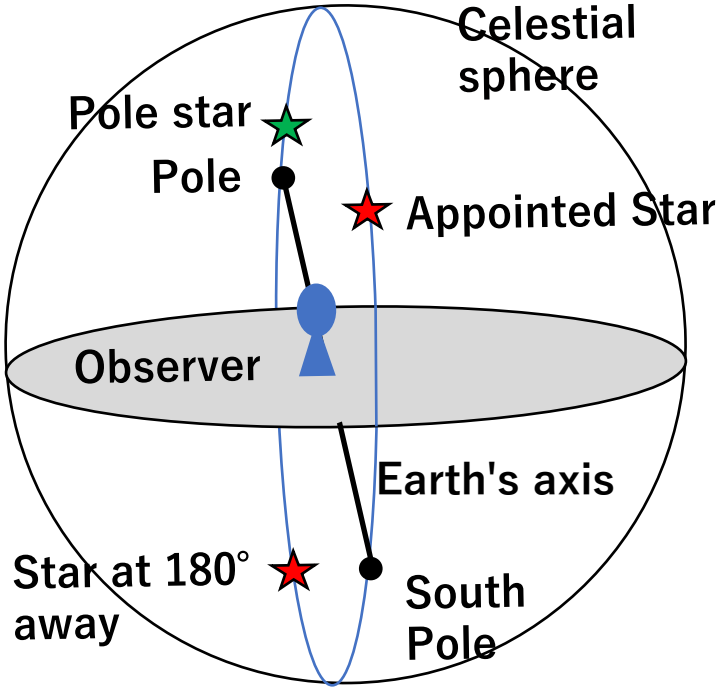
Angle of each Pole Star from the celestial pole

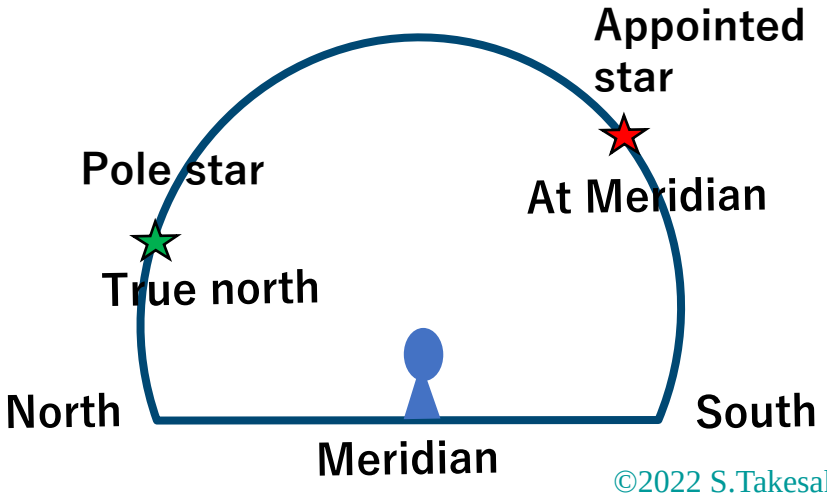


3. Principle of True north measurement by Pole Star

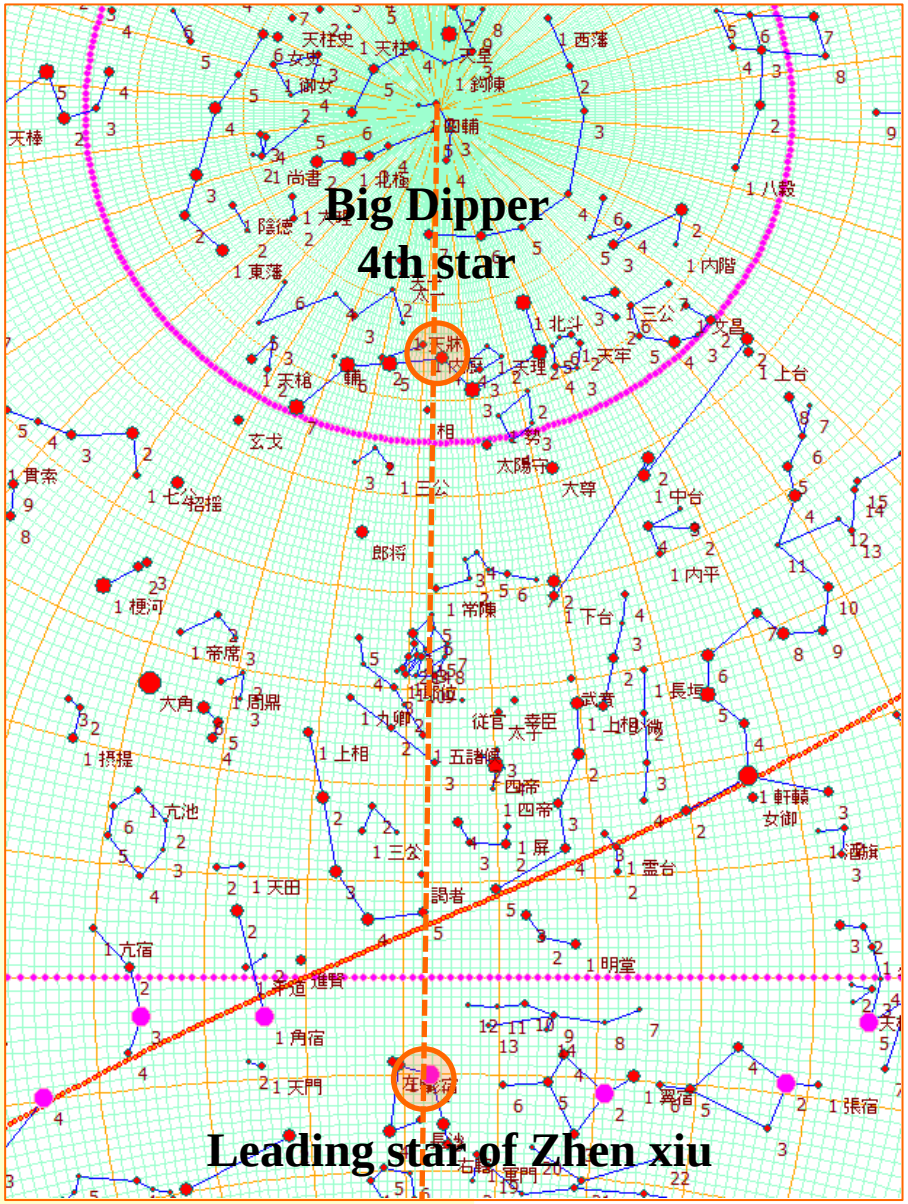
Principle of True north measurement by Pole Star

- The celestial sphere revolves around the earth's axis.
  - The Pole star rotates as well.
- The star south of the Pole Star of the same right ascension and the star 180 degrees away from that star are called appointed stars.
  - The three stars are on the same plane and rotate about the earth's axis.
- When the appointed star is at the meridian, the direction of the pole star is true north.
- Stars 180° away is for measurements in the opposite season.





Example of simultaneous meridian passage of two stars (True north measurements in the Otsukyo period)



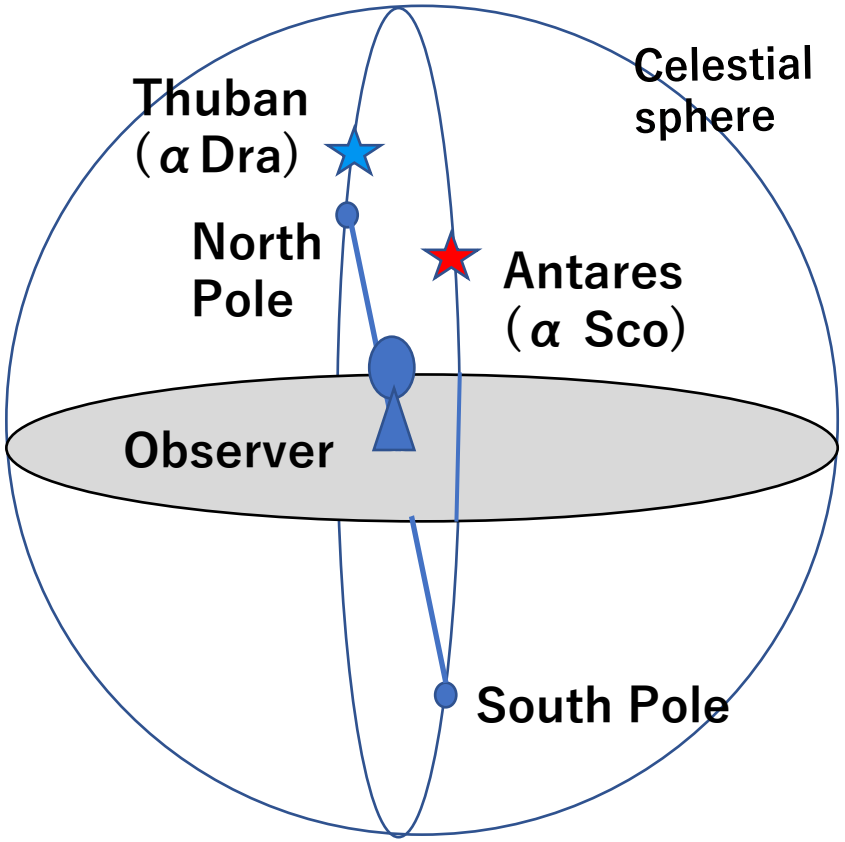
- During the Otsukyo period, when the leading star of Zhen xiu(**軫宿**) was in the south meridian, the direction was measured by looking at the fourth star of the Big Dipper. The resulting direction is 85 minutes west of north.
- If they are on the same line of equatorial longitude, when the south star is on the meridian, the north star is at true north

Position at AD666

BigDipper(4th) HR4460 **赤経:**165.50 **赤緯:** 64.42
Zhen xiu(leadint) HR4662 **赤経:**167.11 **赤緯:**-10.15

Examples of Pole star and Ideal Appointed Star (Egypt, Khufu's Era)

- The Pole star Thuban (αDra, HR5291) and Antares (αSco, HR6134) at the time the pyramids were built have almost the same right ascension.
- At the estimated construction date (2552 BC) of the Pyramid of Khufu (about 3 minutes westward from true noth), Tuvan is about 1.4° away from the celestial pole,
- The direction of Tuban when Antares is mid-southern is 1.2 minutes east of true north, so it is almost an ideal apointing star.
- In order to obtain an direction close to true north, it is important that the star that measures the direction be close to the celestial pole.

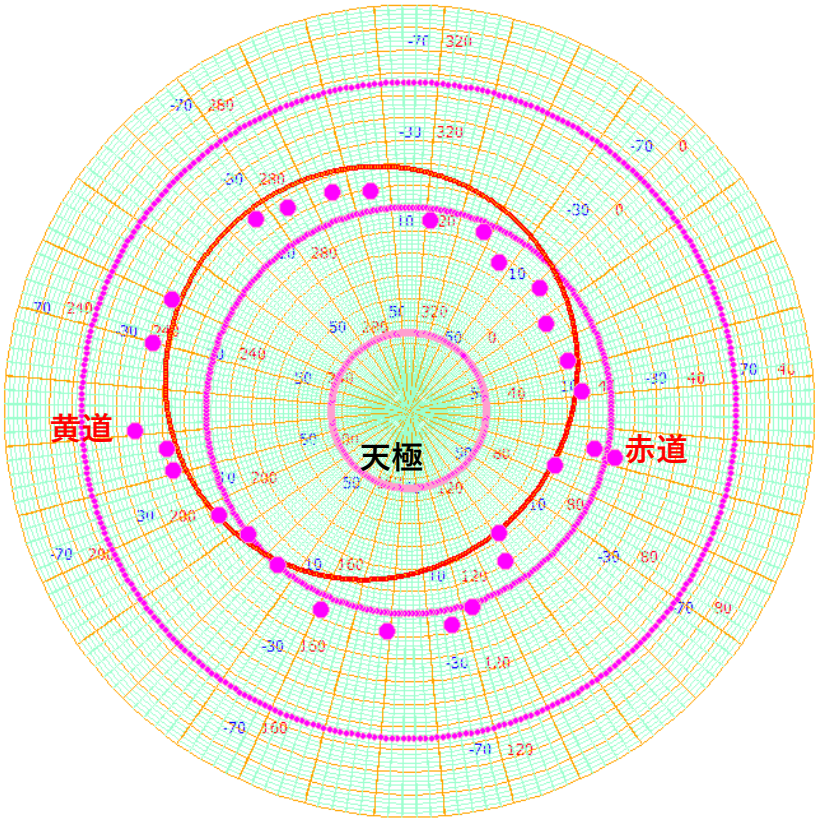


HR	Name	α(BC2552)	δ (BC2552)	Mg
5291	11α Dra	185.3400	88.6091	3.65
6134	21α Sco	184.6354	-6.4197	1.07

28 leading stars were used as Appointed stars

- In China, the twenty-eight constellations of bright leading stars, located near the equator and the ecliptic, were used as reference points for determining the positions of the stars. If you measure the longitude difference from the leading star, the precession is cancelled, and the relative position hardly changes.
  Average interval＝360°/28≒13°
- Since there is usually no bright star at the same right ascension as the Pole Star, which is necessary for true north measurements, the Chinese used a nearby leading star instead of an ideal Appointed star.

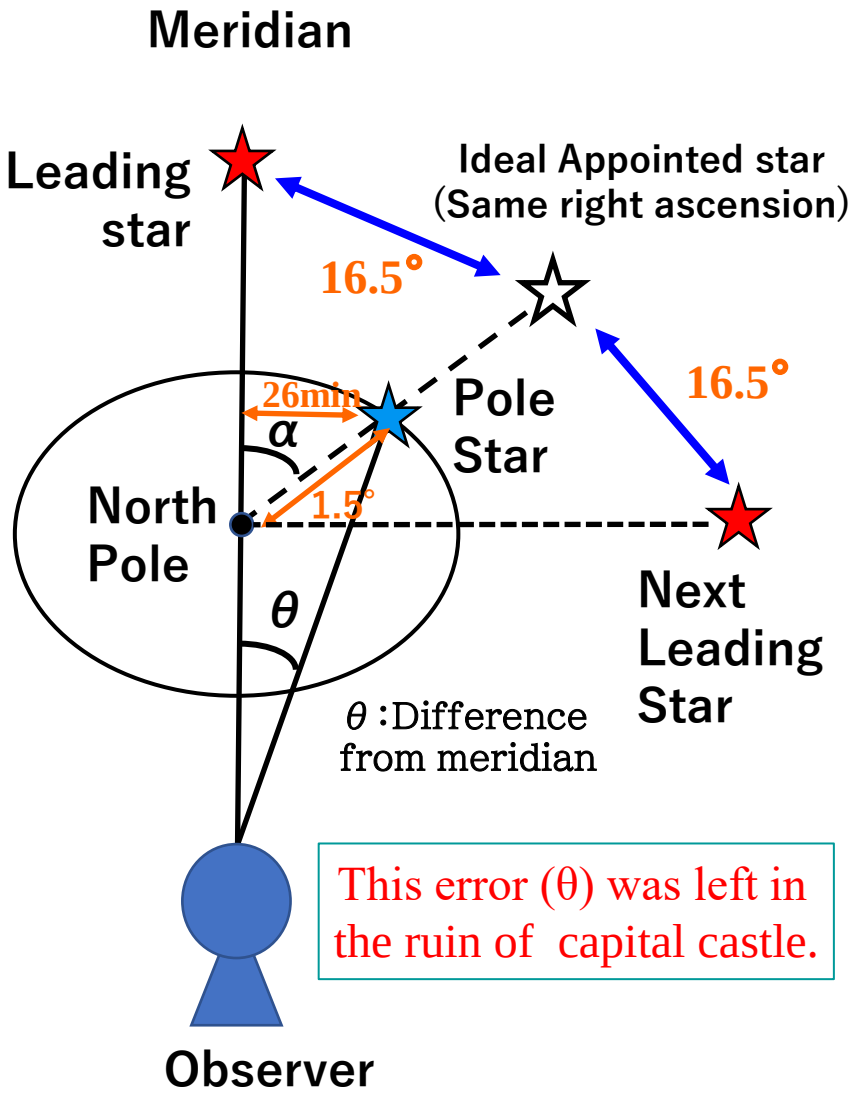
Potion of 28 leading star



【Sky at AD1】

Estimate the error when using 28 leading stars

- The maximum distance between leading stars are 33° . Average is 13° .
- If the Appointed star is properly updated, the maximum value is 16.5° .
- If the Pole star is 1.5 degrees away Maximum error can calculated as
  θ＝ 1.5° x sin(16.5°) ＝26min.
  If use the average, it is about **10 min.**
- This error increases as the Pole Star moves away from the celestial pole, so the star closest to the celestial pole was important and called the Pole Star.
- it was natural to measure the true north with Hokushin, which is ruler in the sky.
- As a result of verification, the optimal leading star is not always selected.



Calculation example of true north measurement with leading stars

- Chang'an Castle was built on **582 AD**. Pole Star(HR4893) is 1.4° away from the pole.
- Since the Pole Star's right ascension is 334°, the Appointed star is Shi xiu or Yi xiu, which is 180° away. . In this example, since Shi xiu is on the meridian during the daytime, Yi xiu will be the Appointed star.
- Without knowing the time when the Pole Star is near the meridian, if you measure the direction at 10p.m., it will be 97 min. west of true north.
- If you measure the direction of Pole star **at 3 o'clock in the morning** when the winged star is on the meridian, you will get the direction of **11.5 minutes to the west of true north.**
- Matches the direction of the remains of the Sui Daxing Castle (582) within a few minutes of error.。

Time (h)	Pole star(HR4893) α	Pole star(HR4893) δ	Leading stars Xiu	Leading stars HR	Leading stars α	Az (min.)
12.16	334.6	88.6	牛	7776	285.0	-75.9
12.65	334.6	88.6	女	7950	292.4	-67.0
13.42	334.6	88.6	虚	8232	303.9	-51.0
14.02	334.6	88.6	危	8414	313.0	-36.9
15.06	334.6	88.6	室	8781	328.7	-10.4
16.17	334.6	88.6	壁	39	345.4	18.6
16.72	334.6	88.6	奎	215	353.6	32.6
17.79	334.6	88.6	婁	553	9.7	57.4
18.53	334.6	88.6	胃	801	20.5	72.0
19.53	334.6	88.6	昴	1142	35.9	87.1
20.27	334.6	88.6	畢	1409	47.0	94.3
21.43	334.6	88.6	觜	1876	64.5	98.5
21.47	334.6	88.6	参	1852	65.1	98.5
22.09	334.6	88.6	井	2286	74.4	96.9
0.28	334.6	88.6	鬼	3357	107.3	71.7
0.48	334.6	88.6	柳	3410	110.4	68.0
1.41	334.6	88.6	星	3748	124.4	49.0
1.84	334.6	88.6	張	3903	130.8	39.2
2.97	334.6	88.6	翼	4287	147.9	11.5
4.18	334.6	88.6	軫	4662	166.1	-19.2
5.31	334.6	88.6	角	5056	183.0	-46.1
6.09	334.6	88.6	亢	5315	194.7	-62.7
6.68	334.6	88.6	氐	5531	203.7	-73.6
7.70	334.6	88.6	房	5944	219.0	-88.2
8.06	334.6	88.6	心	6084	224.4	-91.9
8.42	334.6	88.6	尾	6247	229.8	-94.9
9.69	334.6	88.6	箕	6746	248.9	-98.4
10.38	334.6	88.6	斗	7039	259.3	-95.7

室宿 Shi xiu

180°

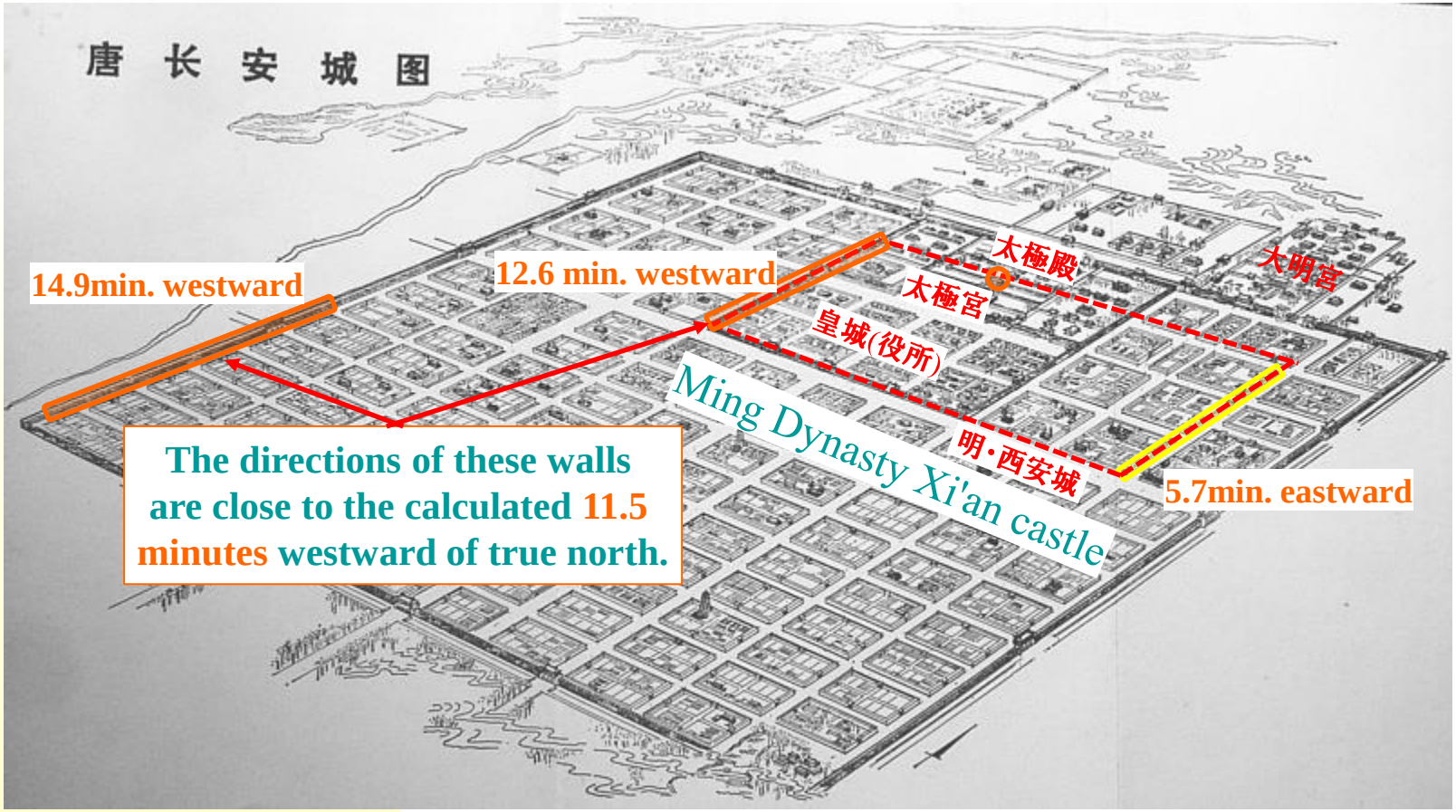
22:00

3:00

Yi xiu 翼宿

Time when the leading star on meridian

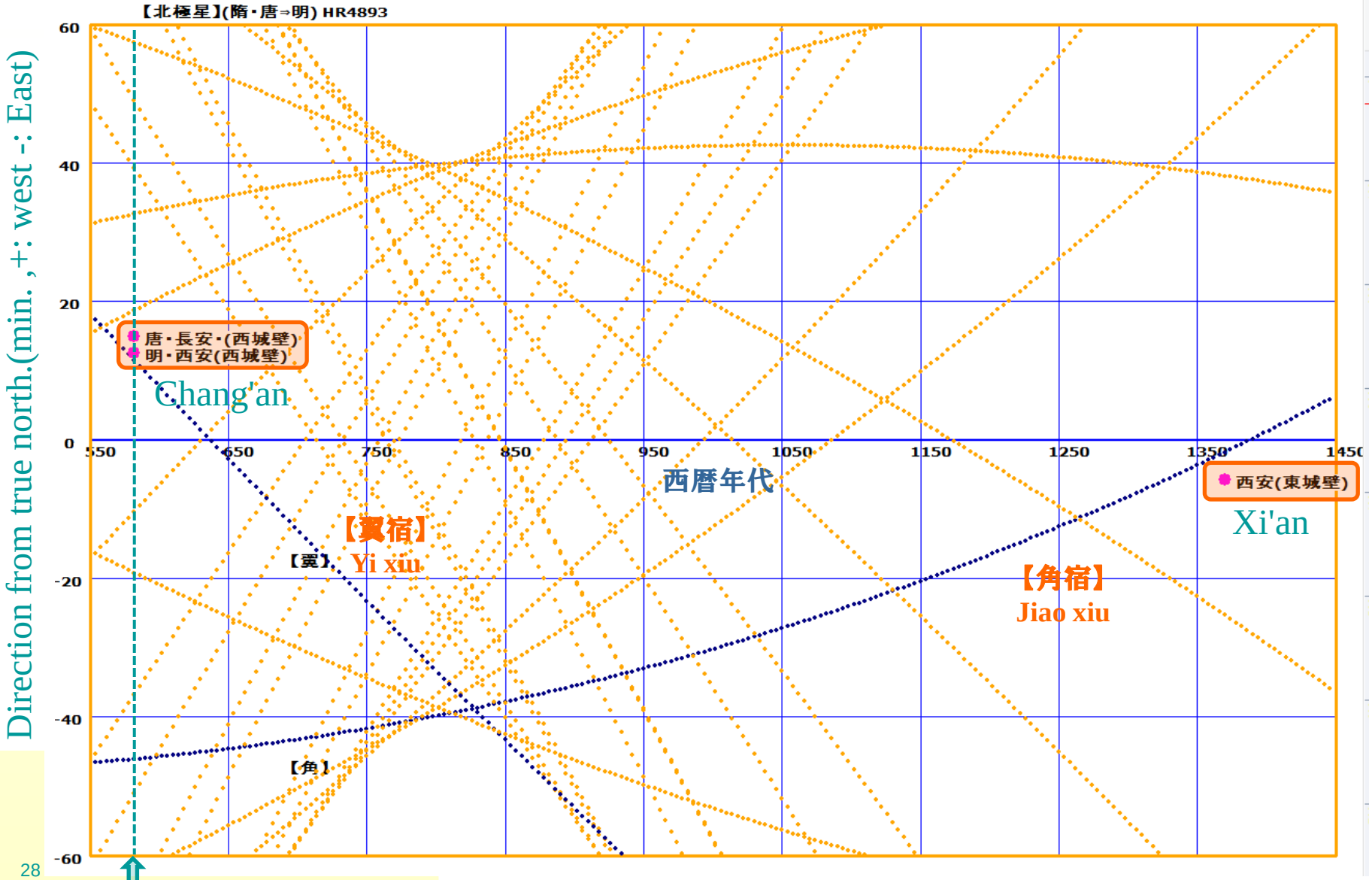
The point of the Direction measurement in the map of Tang Chang'an Castle



【「中国都城歴史図録 第二集」(1986)p.148-149より】

Note: The direction measurement is based on latest image of Google Earth (2021/07/30 version)

Azimuth line by Pole star (HR4893) and leading star and direction of the remains ancient castle



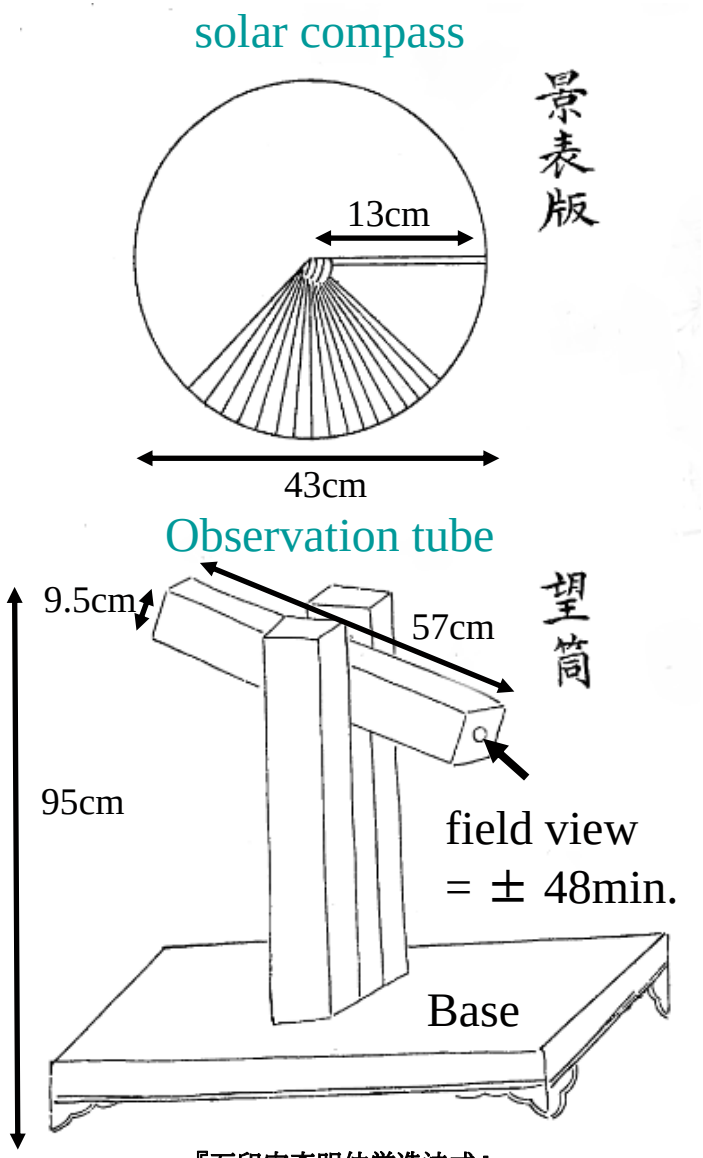
Direction on the page 27.

【Location：34.29° (Chang'an)】

4. True north measurement instruments and methods

True north measuring instrument

- **『営造法式』**"Yíngzào fàshì" was compiled by Li Yi (**李誡**)during the reign of Tiezong of the Song Dynasty. There is an explanation of the true north measurement method using the sun and the Pole Star.
- Measurement uses solar compass and Observation tube without a lens.
- The sun compass is a disc with a diameter of about 43 cm and a gnomon about 13 cm high (3 mm in diameter) is placed in the center.
- Observation tube is 57cm long and 9.5cm wide. Viewing holes with a diameter of 16 mm are drilled in the front and rear plates of it. The field of viewing hole is about 1.6 degrees in angle . The height of Observation tube is 95 cm above the ground, and the line-of-sight distance on flat ground is about 3.5 km. A long distance is also possible if you set up scaffolding.

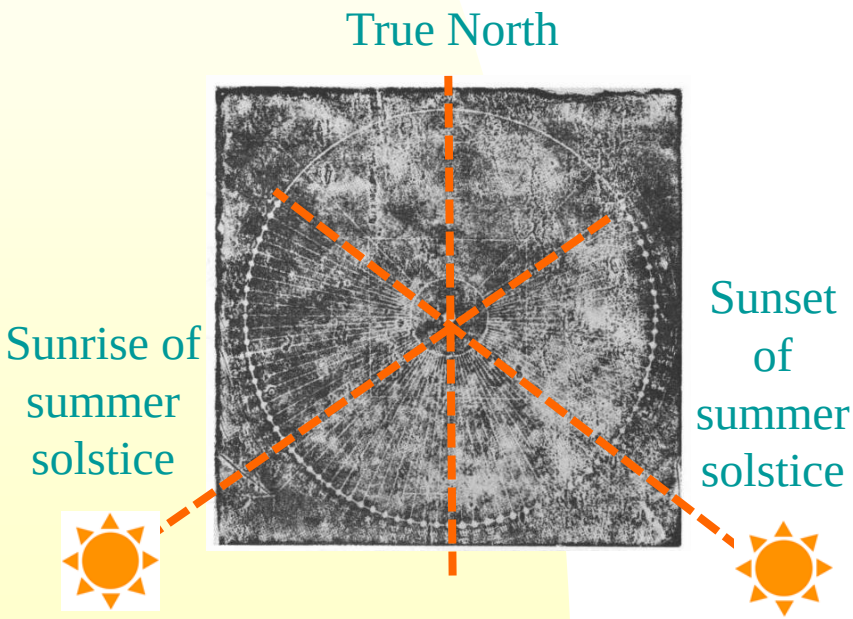


『石印宋李明仲営造法式』
東北大学附属図書館蔵

Similar Observation Instruments Exist in Ancient Times

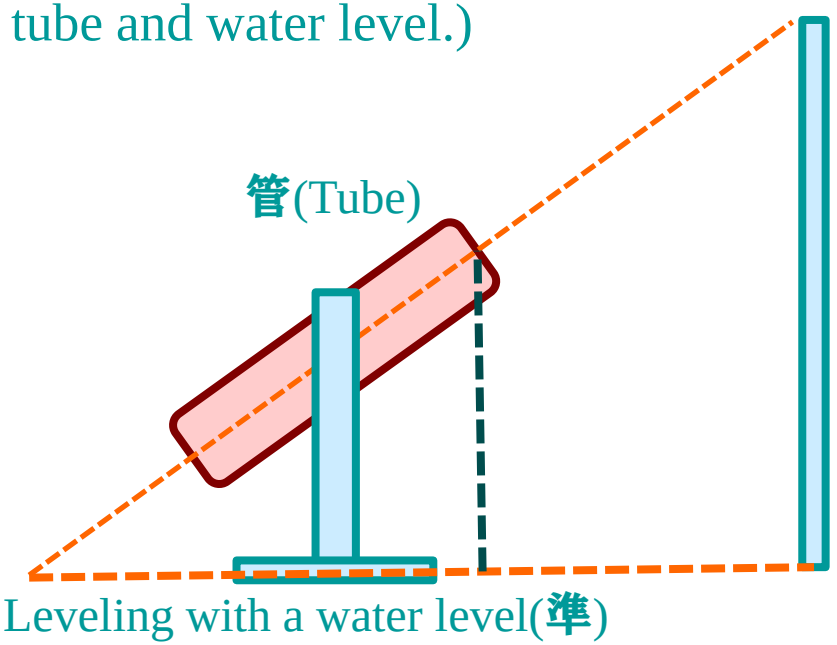
① Han Dynasty sun compass (excavated)

- Although it is explained as a sundial in various places, it is actually a compass of the sun.



② Observation tube

- 『淮南子』(Former Han)
  「人欲知高下而不能,教之用管準則説」
  (If someone does not know the height of the object, please instruct them to use a tube and water level.)

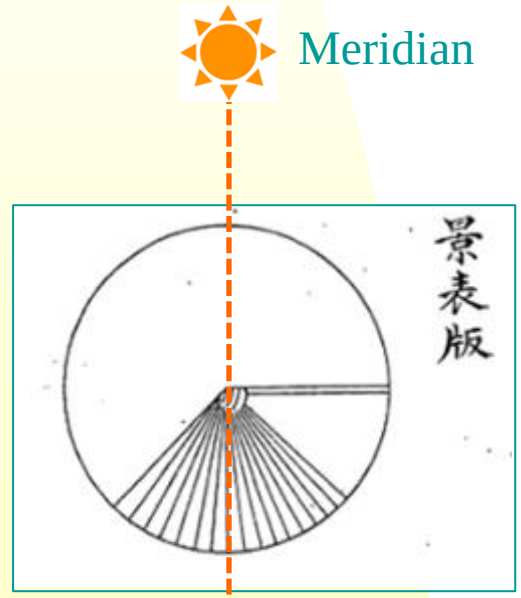


Work at daytime: Installation of the telescope-like device on the temporary meridian

The purpose is to limit the range to search for the faint Pole Star to the vicinity of the meridian.

①If there is no bell to signal the Noon

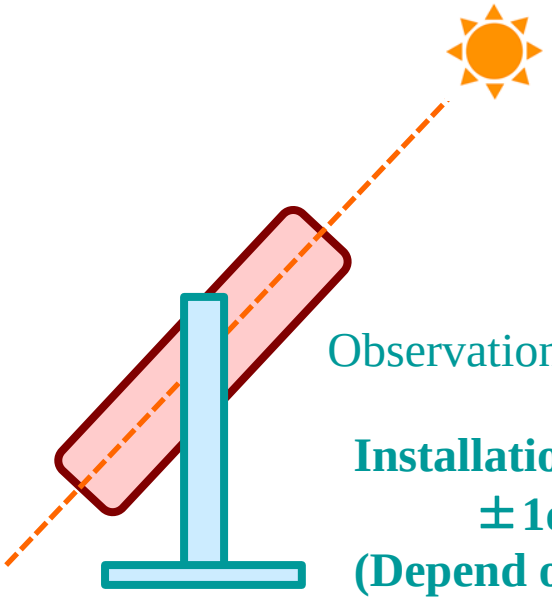
- The point where the shadow of the stick is the shortest is the mid-south of the sun, which is the north-south line (meridian).



Installation accuracy：±few deg.

②If there is bell to signal the Noon

- place the tube on the meridian by passing sunlight at noon. Ancient time is true solar time, so at noon the sun is due south.



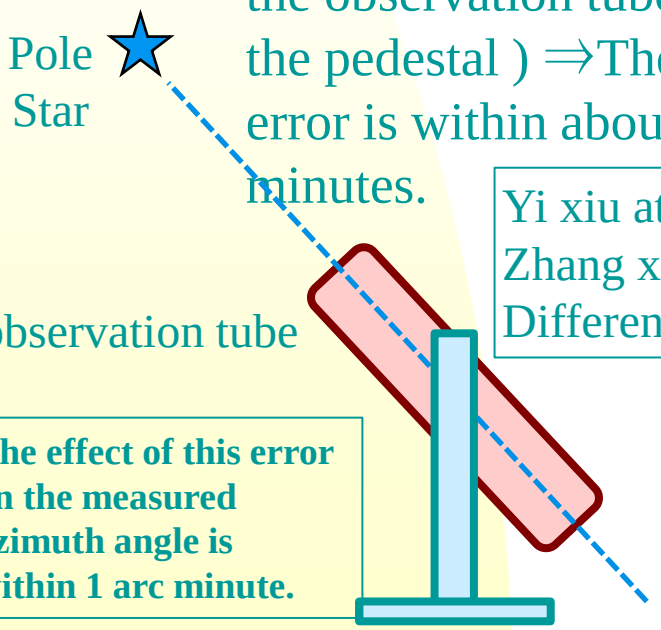
Installation accuracy:
±1degree
(Depend oh the clock)

Work at nighttime①: Introducing Pole Star

To reduce the installation error of the observation tube.

Pre-setting of pole stars

- Before observing the Appointed star in the south, capture the Pole Star and and introduced into the center of the observation tube. (Fine-adjust the pedestal) ⇒The installation error is within about ±30 arc minutes.



Yi xiu at meridian: 3:00
Zhang xiu at meridian: 2:00
Difference is about 30 arc min.

Setting error :±30 arc minutes.

The effect of this error on the measured azimuth angle is within 1 arc minute.

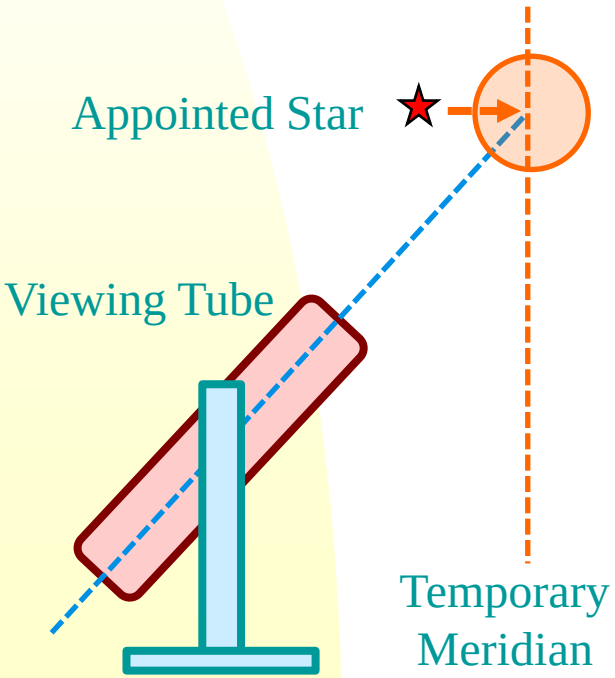
Time (h)	Pole star(HR4893) α	Pole star(HR4893) δ	Leading stars Xiu	Leading stars HR	Leading stars α	Az (min.)
12.16	334.6	88.6	牛	7776	285.0	-75.9
12.65	334.6	88.6	女	7950	292.4	-67.0
13.42	334.6	88.6	虚	8232	303.9	-51.0
14.02	334.6	88.6	危	8414	313.0	-36.9
15.06	334.6	88.6	室	8781	328.7	-10.4
16.17	334.6	88.6	壁	39	345.4	18.6
16.72	334.6	88.6	奎	215	353.6	32.6
17.79	334.6	88.6	婁	553	9.7	57.4
18.53	334.6	88.6	胃	801	20.9	72.0
19.53	334.6	88.6	昴	1142	35.9	87.1
20.27	334.6	88.6	畢	1409	47.0	94.3
21.43	334.6	88.6	觜	1876	64.5	98.5
21.47	334.6	88.6	参	1852	65.1	98.5
22.09	334.6	88.6	井	2286	74.4	96.9
0.28	334.6	88.6	鬼	3357	107.3	71.7
0.48	334.6	88.6	柳	3410	110.4	68.0
1.41	334.6	88.6	星	3748	124.4	49.0
1.84	334.6	88.6	張	3903	130.8	39.2
2.97	334.6	88.6	翼	4287	147.9	11.5
4.18	334.6	88.6	軫	4662	166.1	-19.2
5.31	334.6	88.6	角	5056	183.0	-46.1
6.09	334.6	88.6	亢	5315	194.7	-62.7
6.68	334.6	88.6	氐	5531	203.7	-73.6
7.70	334.6	88.6	房	5944	219.0	-88.2
8.06	334.6	88.6	心	6084	224.4	-91.9
8.42	334.6	88.6	尾	6247	229.8	-94.9
9.69	334.6	88.6	箕	6746	248.9	-98.4
10.38	334.6	88.6	斗	7039	259.3	-95.7

Work a nighttime②: Measure the direction after observing the Appointed star at meridian

The method with Appointed star enables accurate survey in one day.

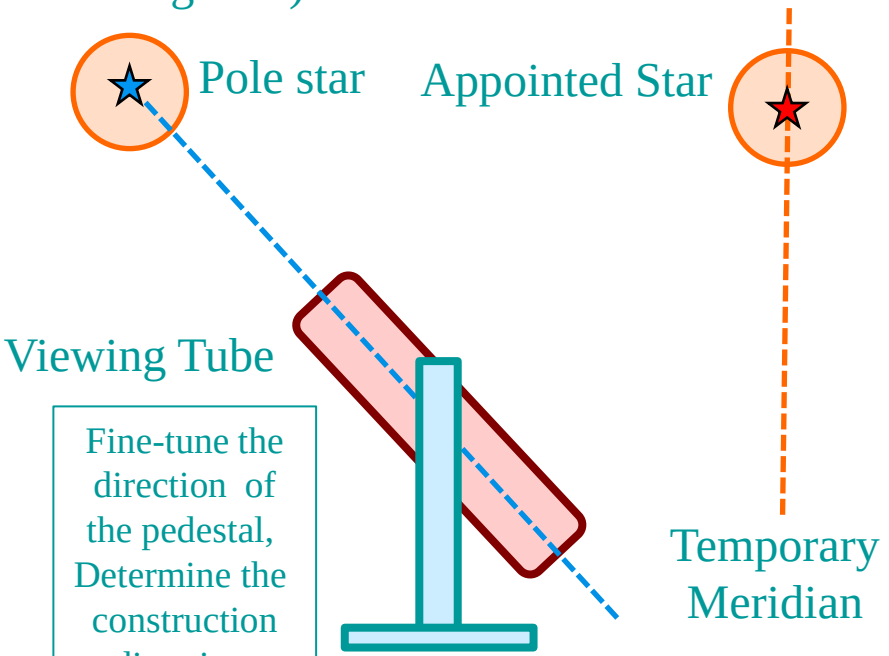
①Observe Appointed star at meridian

- Point the viewing tube to the south and observe the zenith of Appointed star. Wait for the fixed star to come to the center of the telescope.



②Observing the pole star to determine the direction of the north

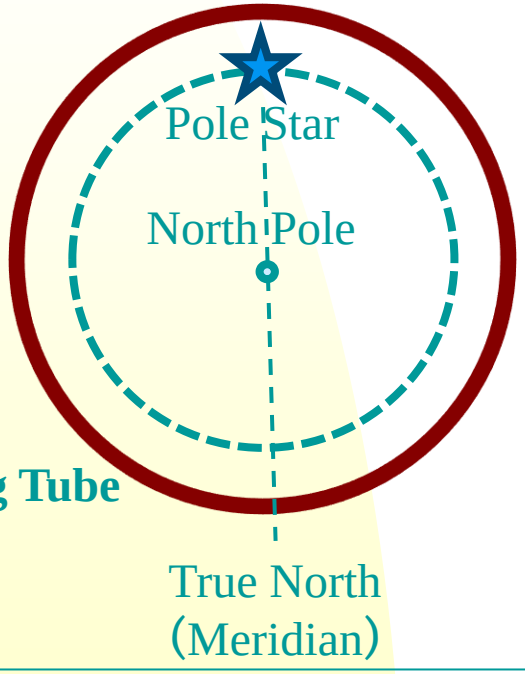
- When the Appointed star comes on the meridian, reverse the viewing tube and introduce the pole star into the center of the tube. (Fine tune the pedestal of viewing tube)



How to select the best Appointed star

① Find true north

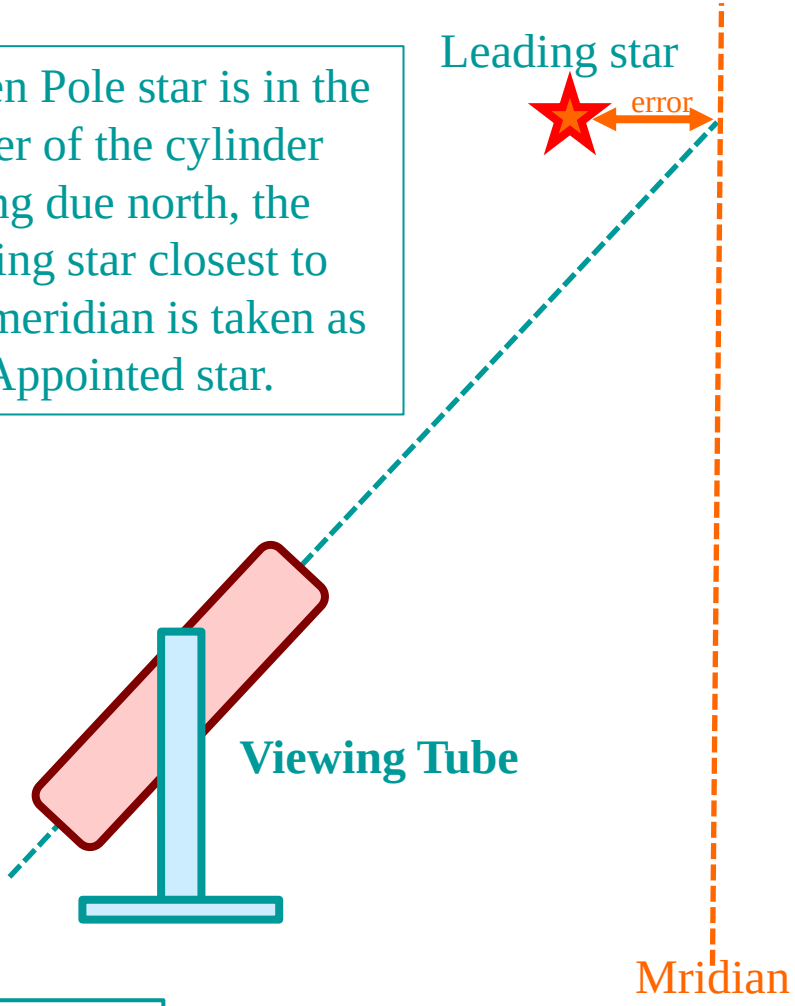
by orbiting the pole star in the tube,
the viewing tube is turned to true north.



It takes months to determine the true north.

② the leading star closest to the meridian

When Pole star is in the center of the cylinder facing due north, the leading star closest to the meridian is taken as the Appointed star.

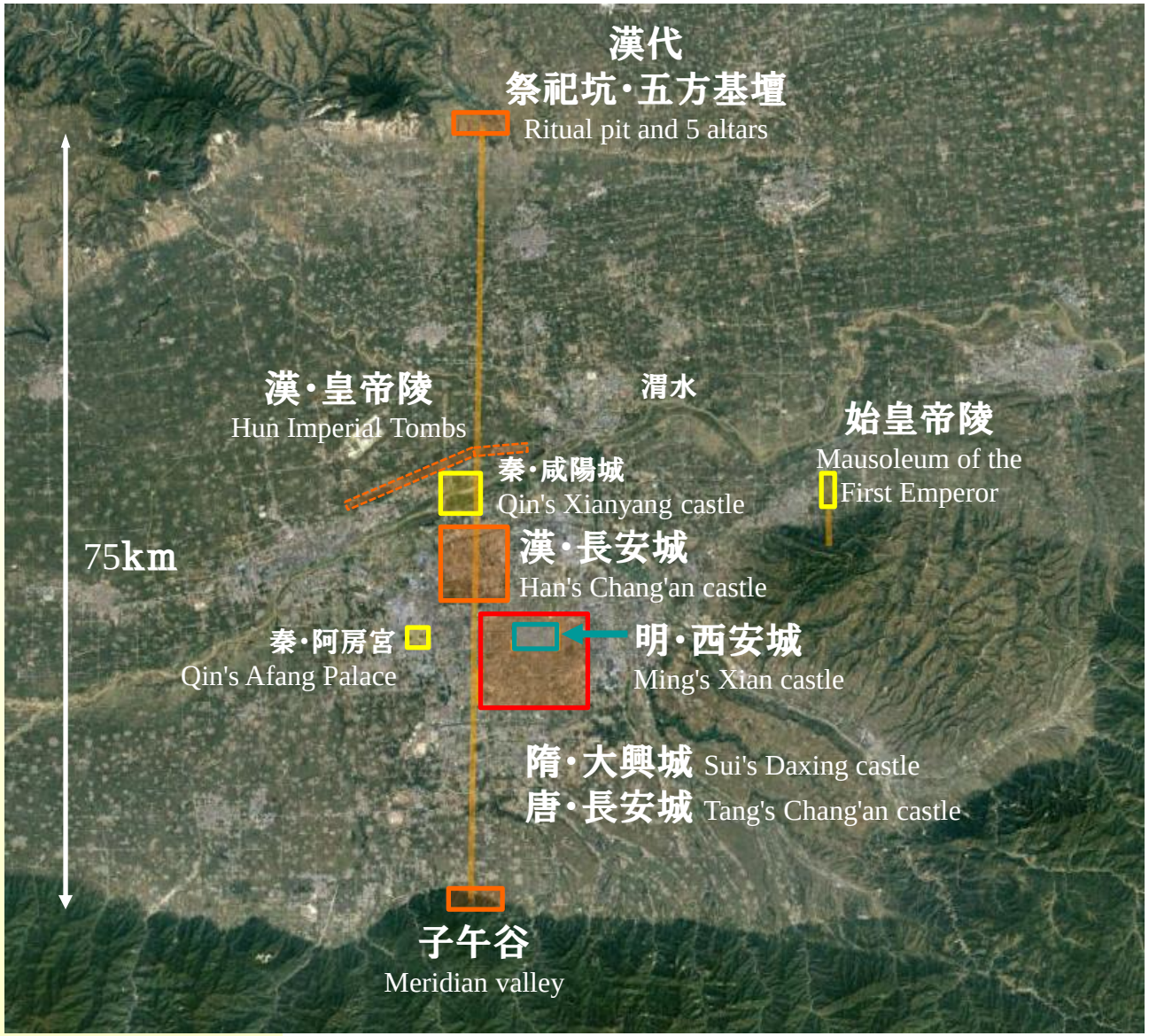


Not mentioned in「営造法式」

5. Verification of the remains of ancient ruins in China.

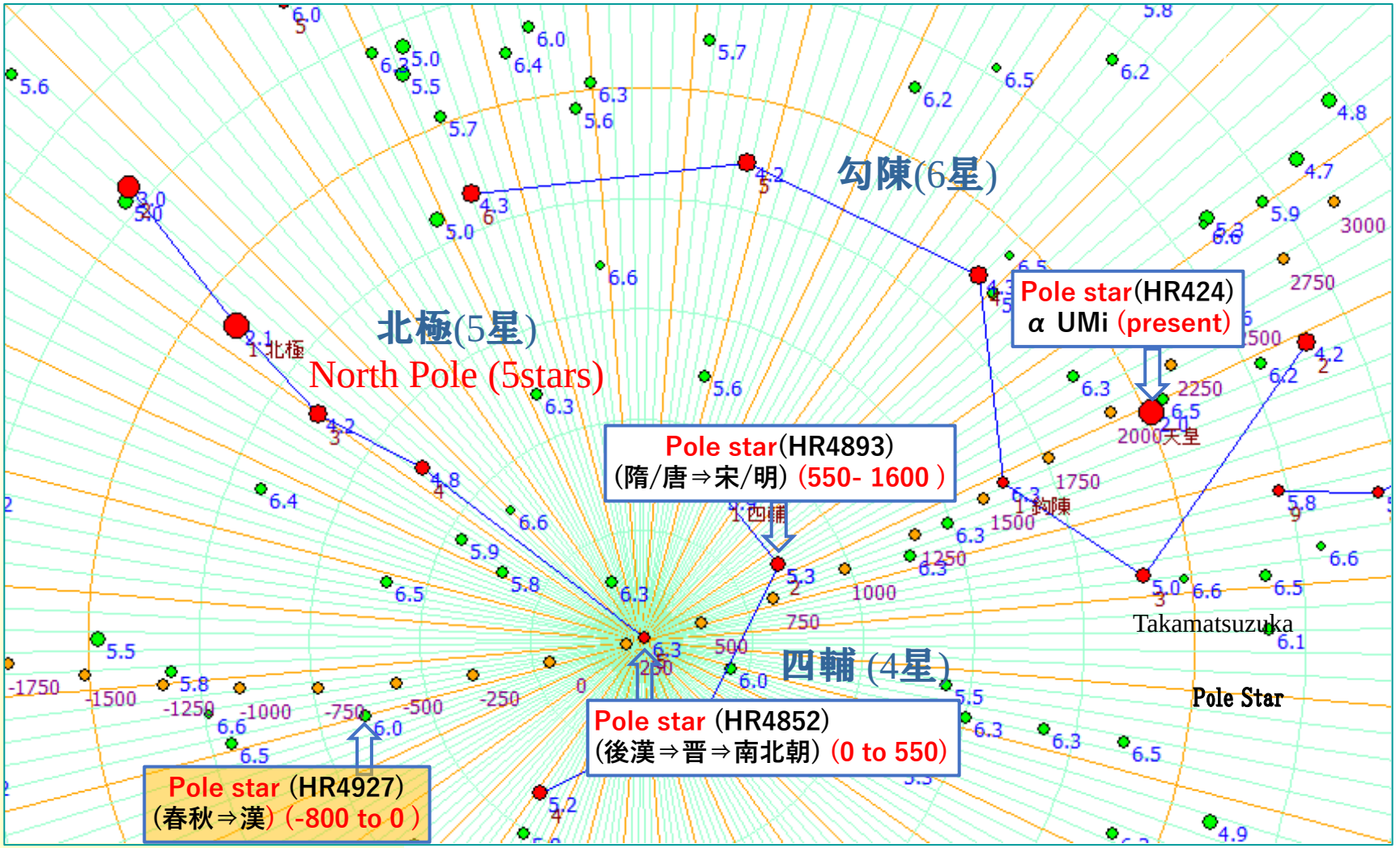
Location of Ancient Chinese Cities

Positional relationship of ruins around Chang'an



Ruins from Chunqiu era to the Former Han Dynasty :Pole Star(HR4927)

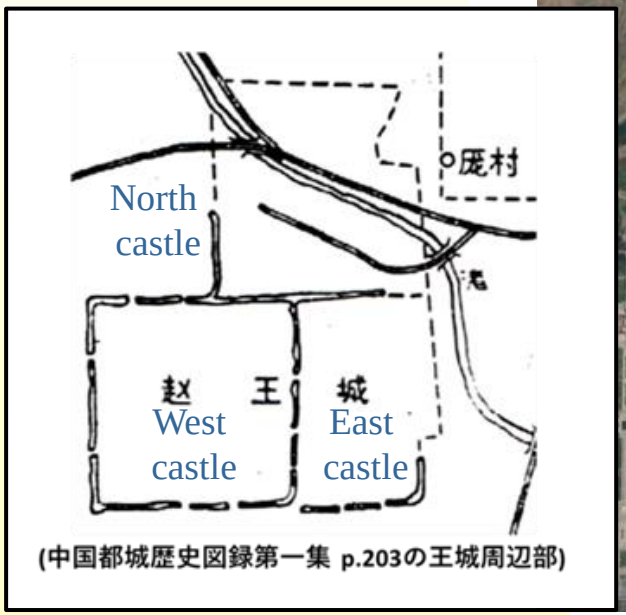
Chinese constellations based on the identification of the original map of the Jin dynasty (created in early Tang Dynasty).

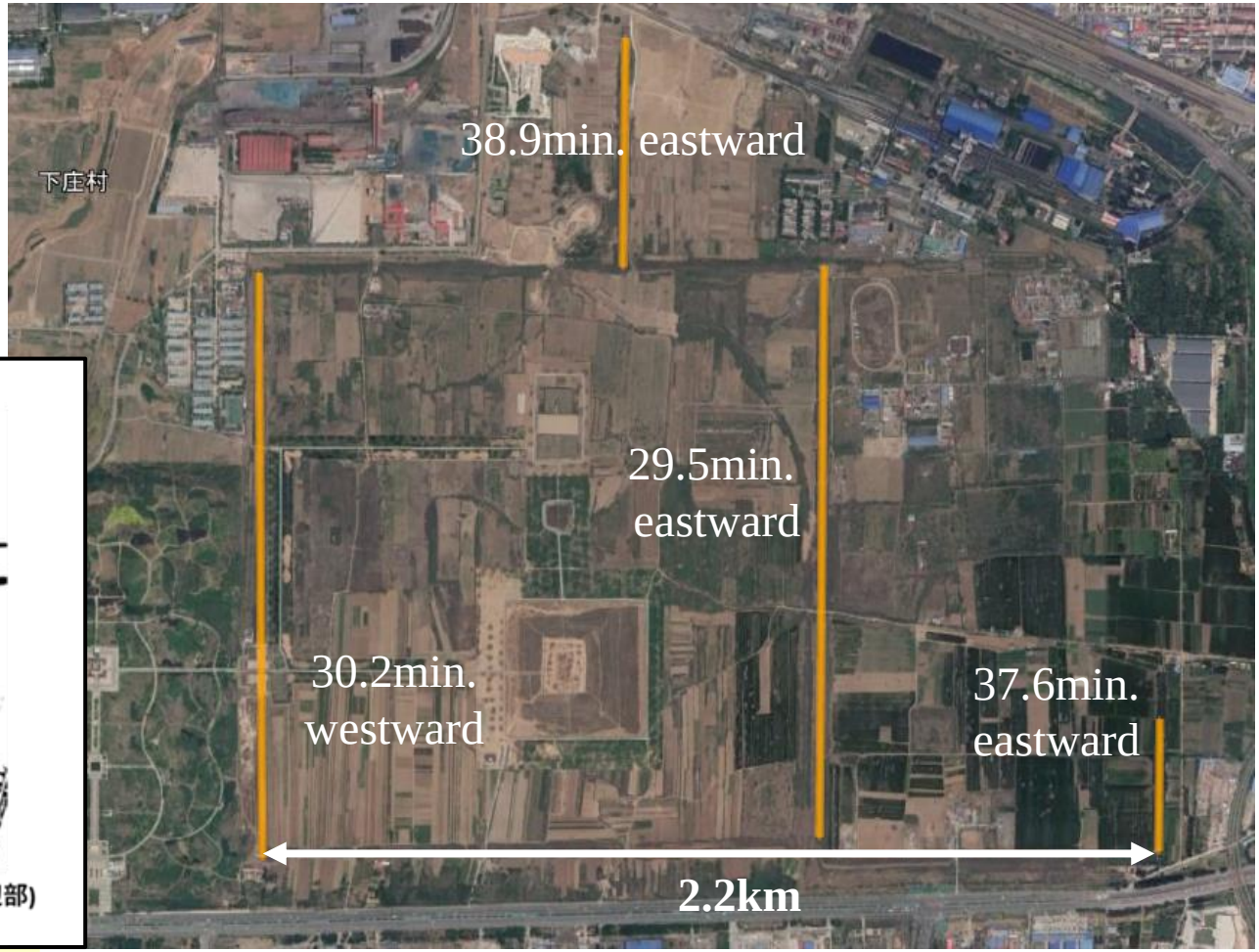


Note: Position at AD300

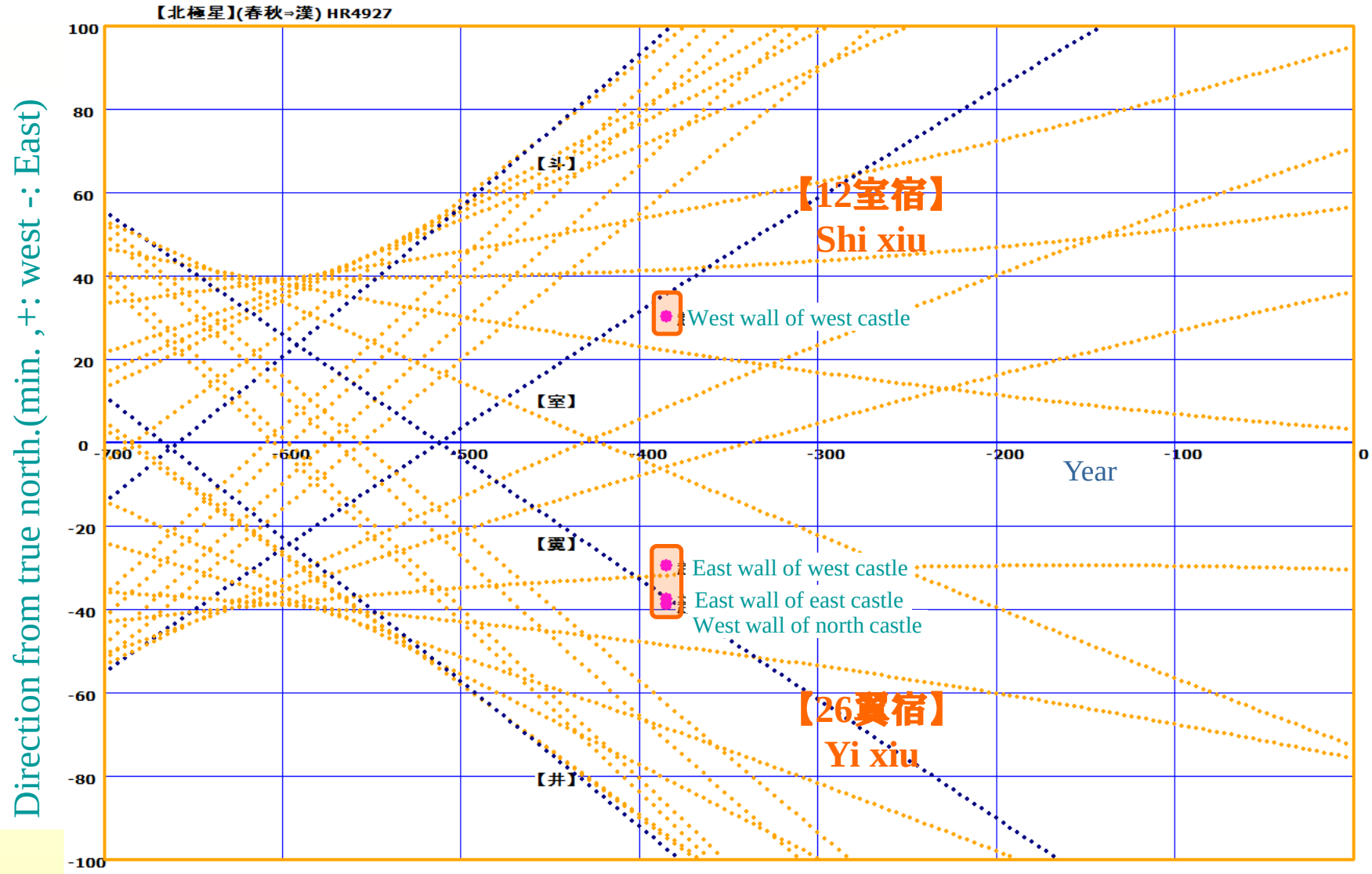
Orientation of Zhao royal castle (oldest verified remains)

The capital of Zhao was moved to Handan in 386 BC during the Warring States period. Even now, the remains of the four north and south castle walls of the royal castle remain.





Azimuth line by Pole star (HR4927) and direction of the remains of Zhao royal castle



【Longitude：36.57°（Zhao royal castle ）】

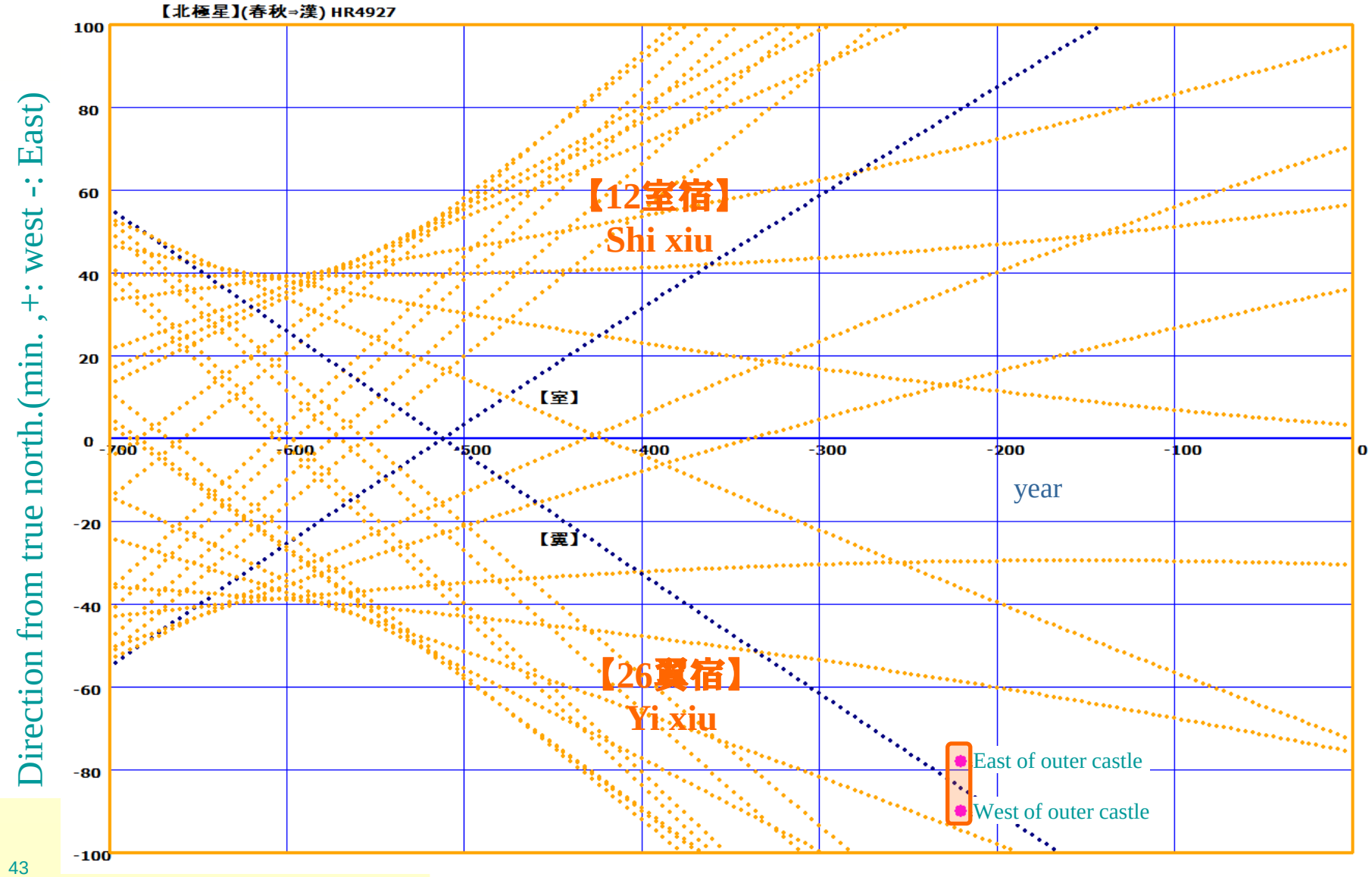
Direction of Qin Shi Huang Mausoleum

The location of the base of the mound is unclear. Masahiro Etaya et al. (2014) measured the boundary stones of the outer castle , the direction of the central axis is average of 1.4 degrees (84 minutes) east of true north.

Construction of the mausoleum began when he was 13 years old when he ascended the throne as a royal tomb of Qin. Furthermore, it is believed that it was expanded as an imperial mausoleum with the unification of China (221 BC).

Assuming that the survey after the enlargement are made around the time of national unification (221 BC), using Pole star HR4927 and leading star of Yi xiu , the direction is 84.7 minutes east of true north, which is almost the same as the measured average.

Azimuth line by Pole star (HR4927) and direction of the Qin Shi Huang Mausoleum

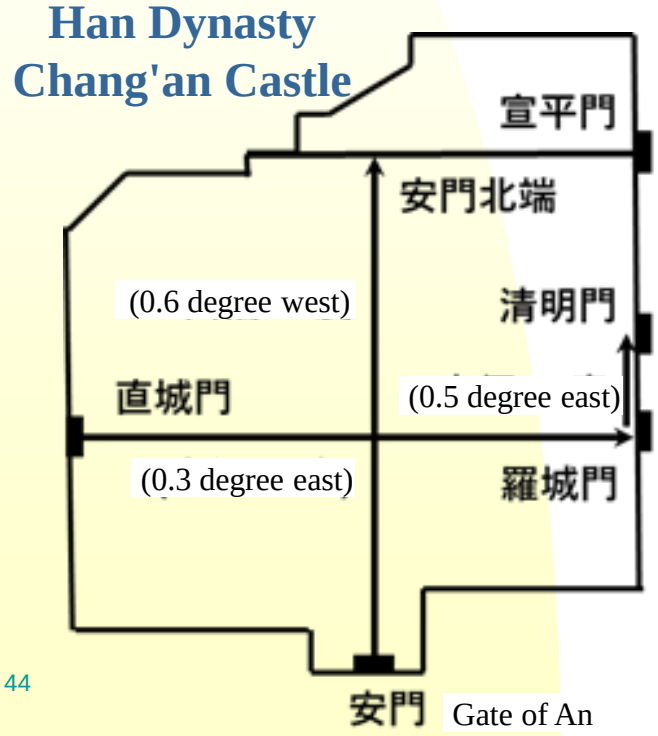


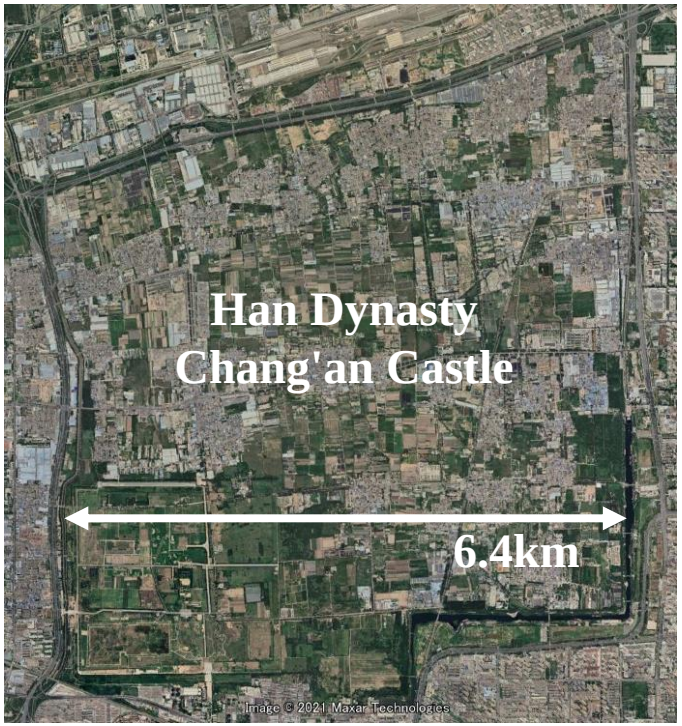
【Latitude：34.29°（Chang'an)】

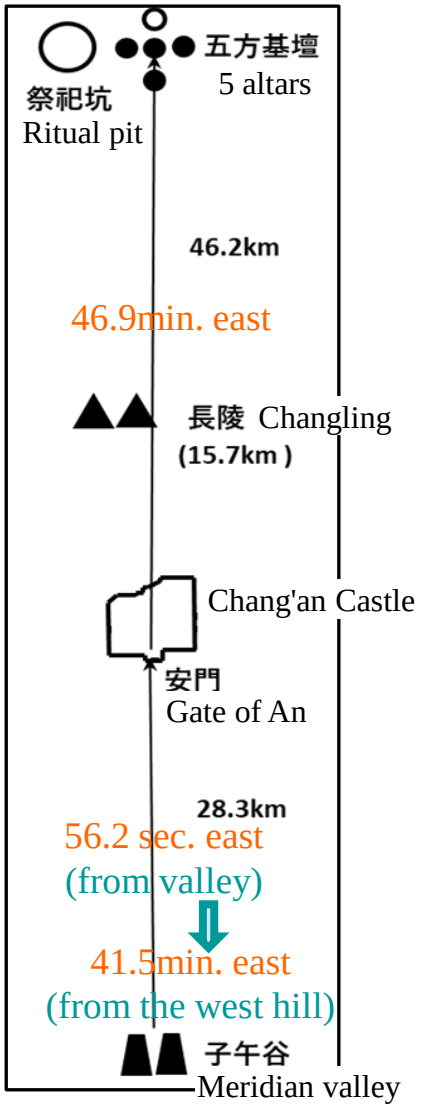
Direction of Former Han Dynasty Chang'an Castle

- Chang'an Castle：Construction began in 202 BC
- Castle wall：Construction began t in 195 BC

- Ms. Huang(**黃曉芬**(2006)) envisioned a 75 km central axis line and measured and verified it with GPS.
- Measurements of direction inside the castle by Mr. Uno
- 4th Emperor's Mausoleum(Yangling):19.2minutes west



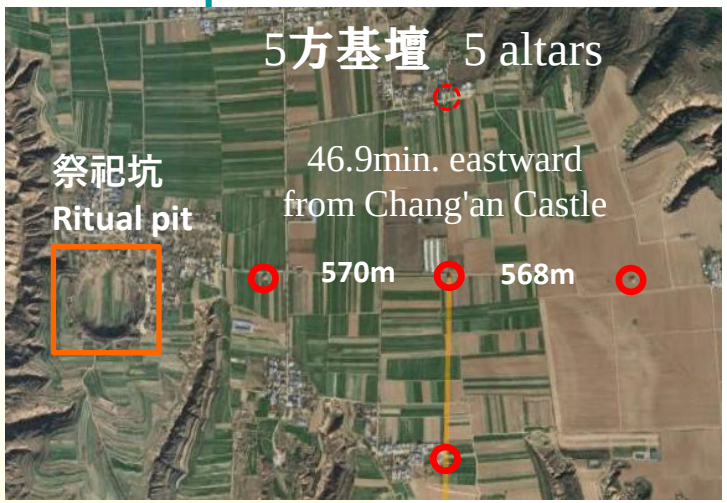




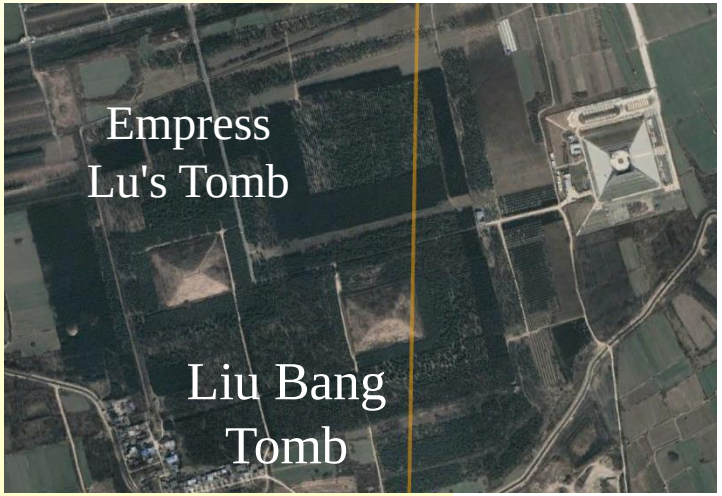
Positional relationship of ruins around Chang'an Castle

5 altars, Changling and Meridian Valley

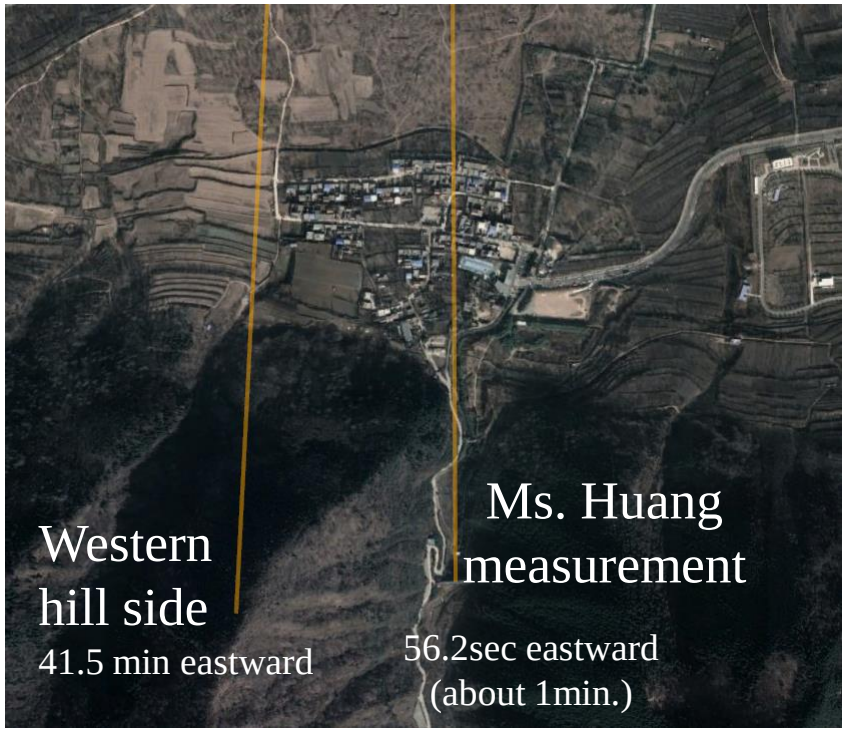
Ritual pit and the 5 altars



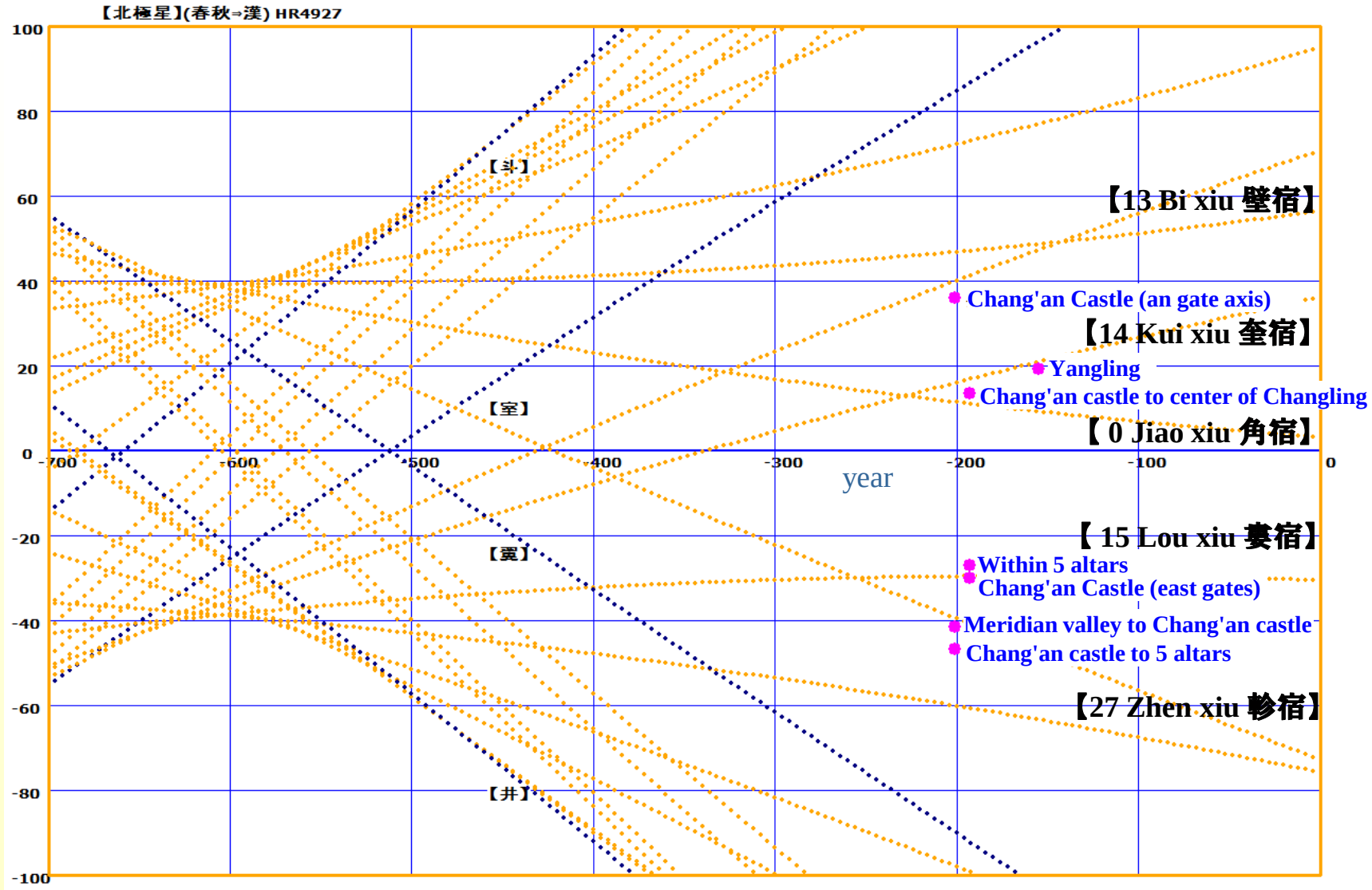
Changling (長陵)



Meridian Valley (子午谷)

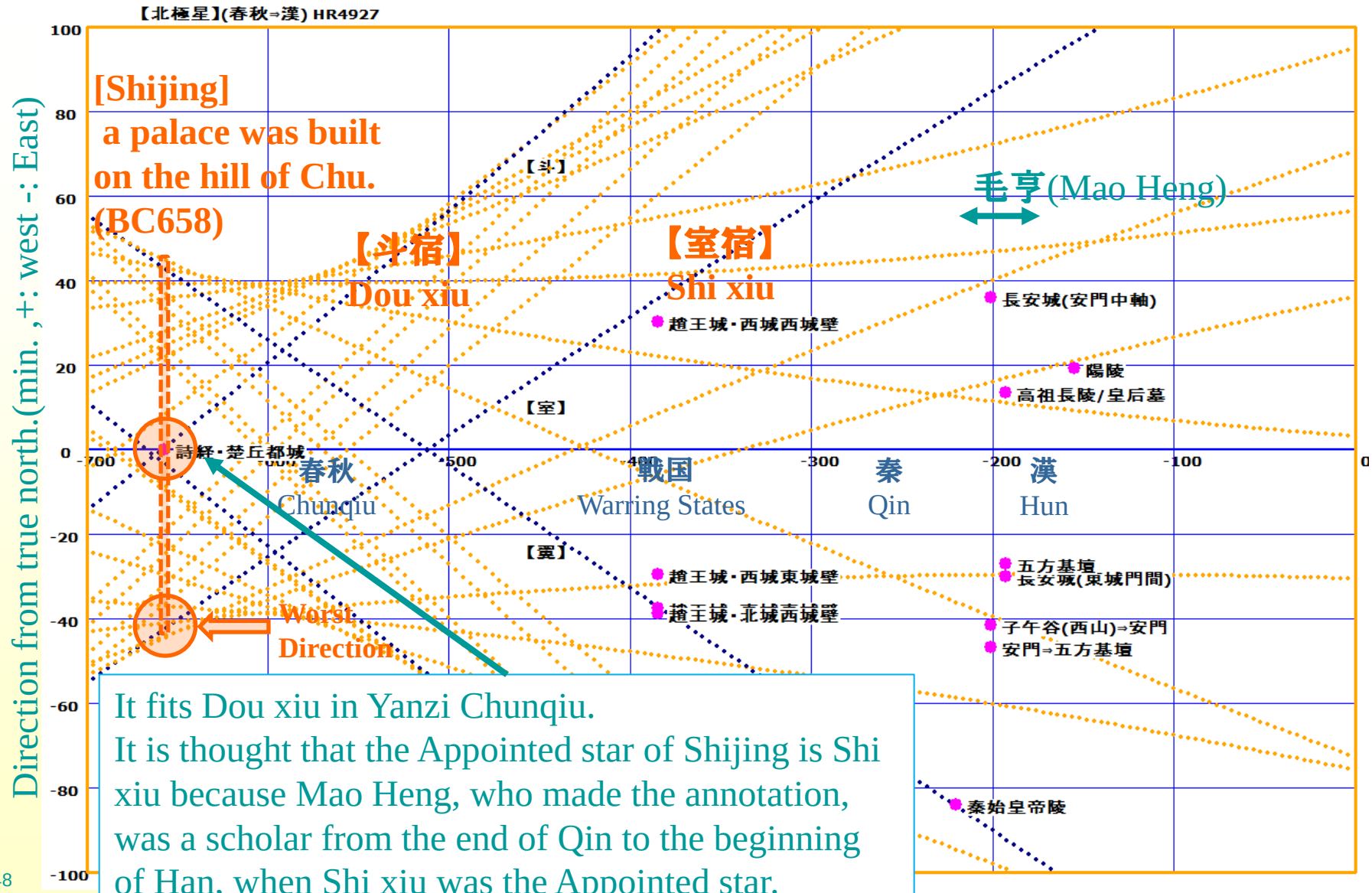


Azimuth line by Pole star (HR4927) and direction of the ruins around Chang'an Castle



【Latitude：34.29° (Chang'an)】

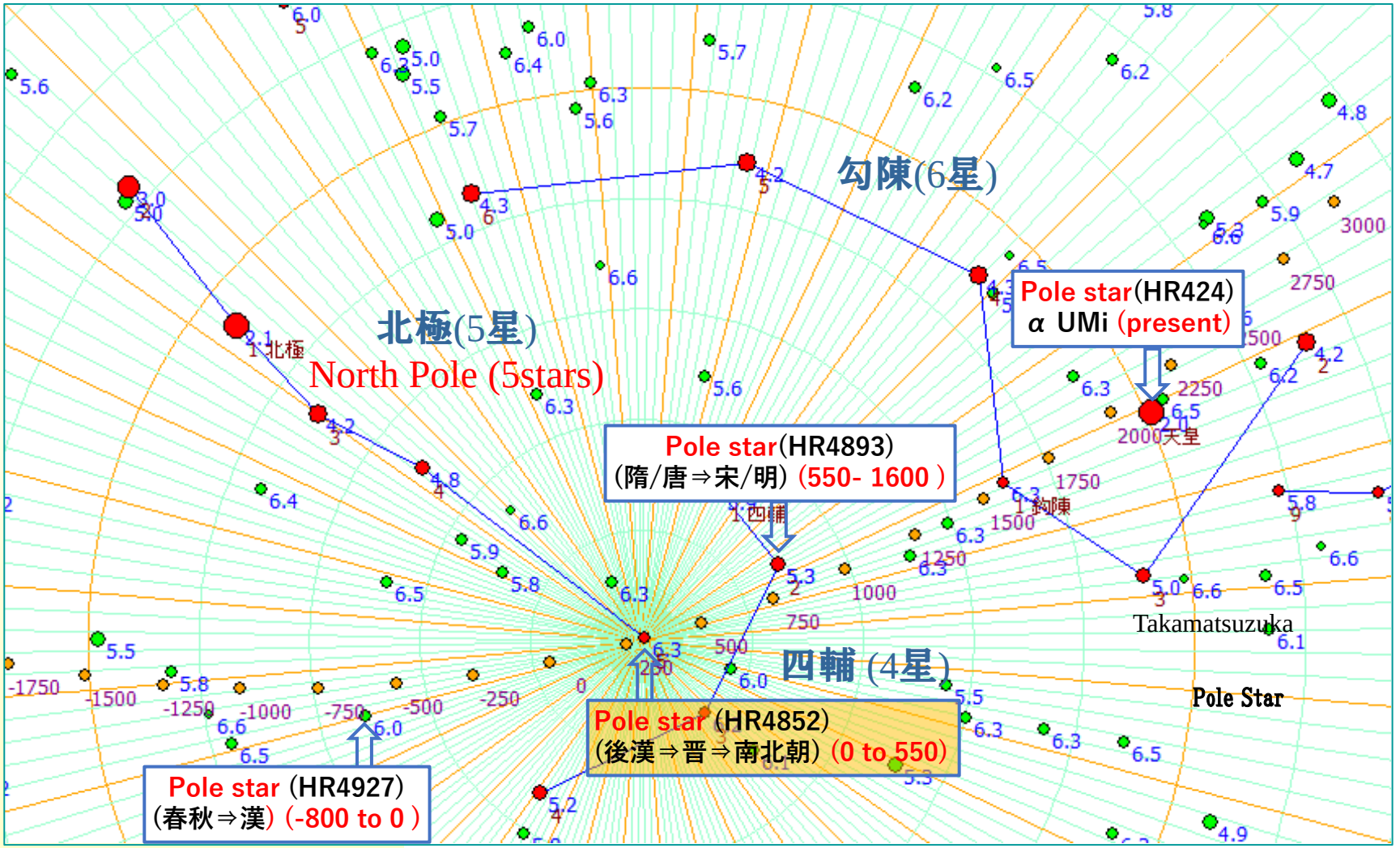
Azimuth line by Pole star (HR4927) and direction of the ruins



It fits Dou xiu in Yanzi Chunqiu.
It is thought that the Appointed star of Shijing is Shi xiu because Mao Heng, who made the annotation, was a scholar from the end of Qin to the beginning of Han, when Shi xiu was the Appointed star.

Ruins from the Later Han to the Northern and Southern Dynasties :Pole Star(HR4927)

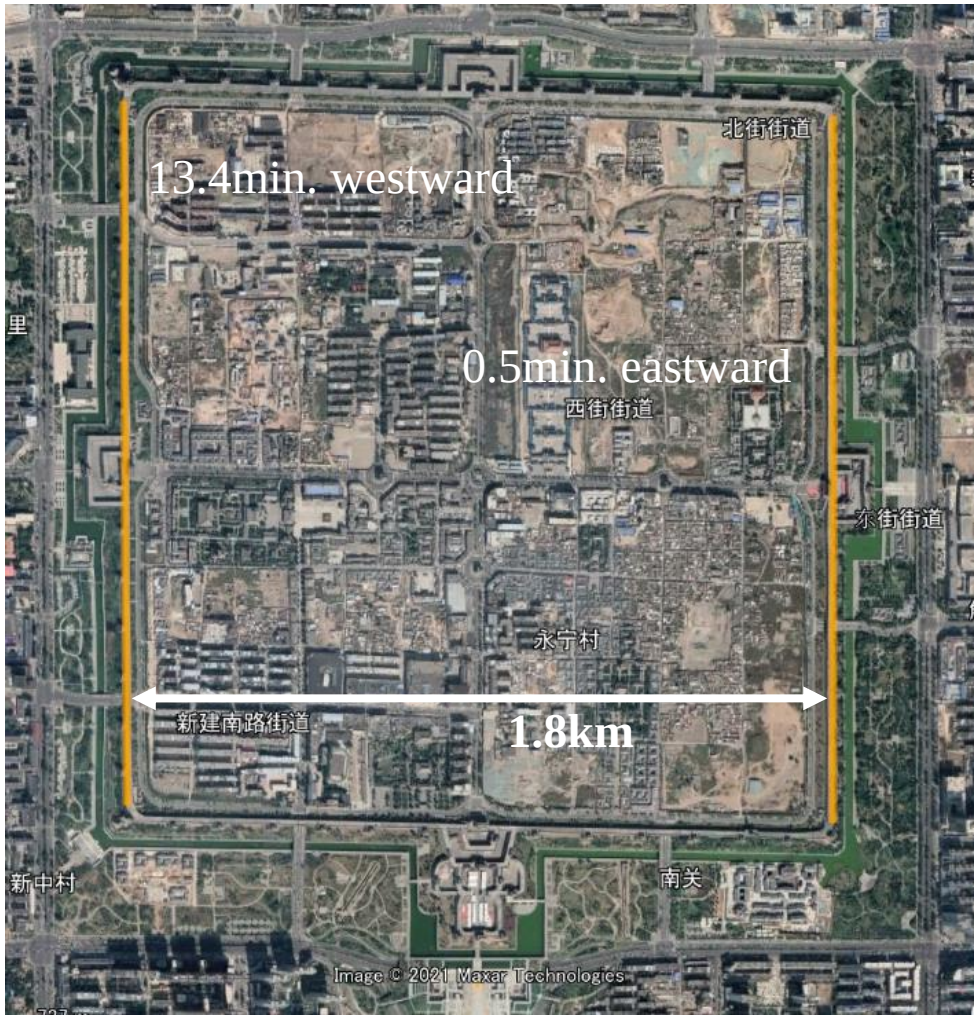
Chinese constellations based on the identification of the original map of the Jin dynasty (created in early Tang Dynasty).



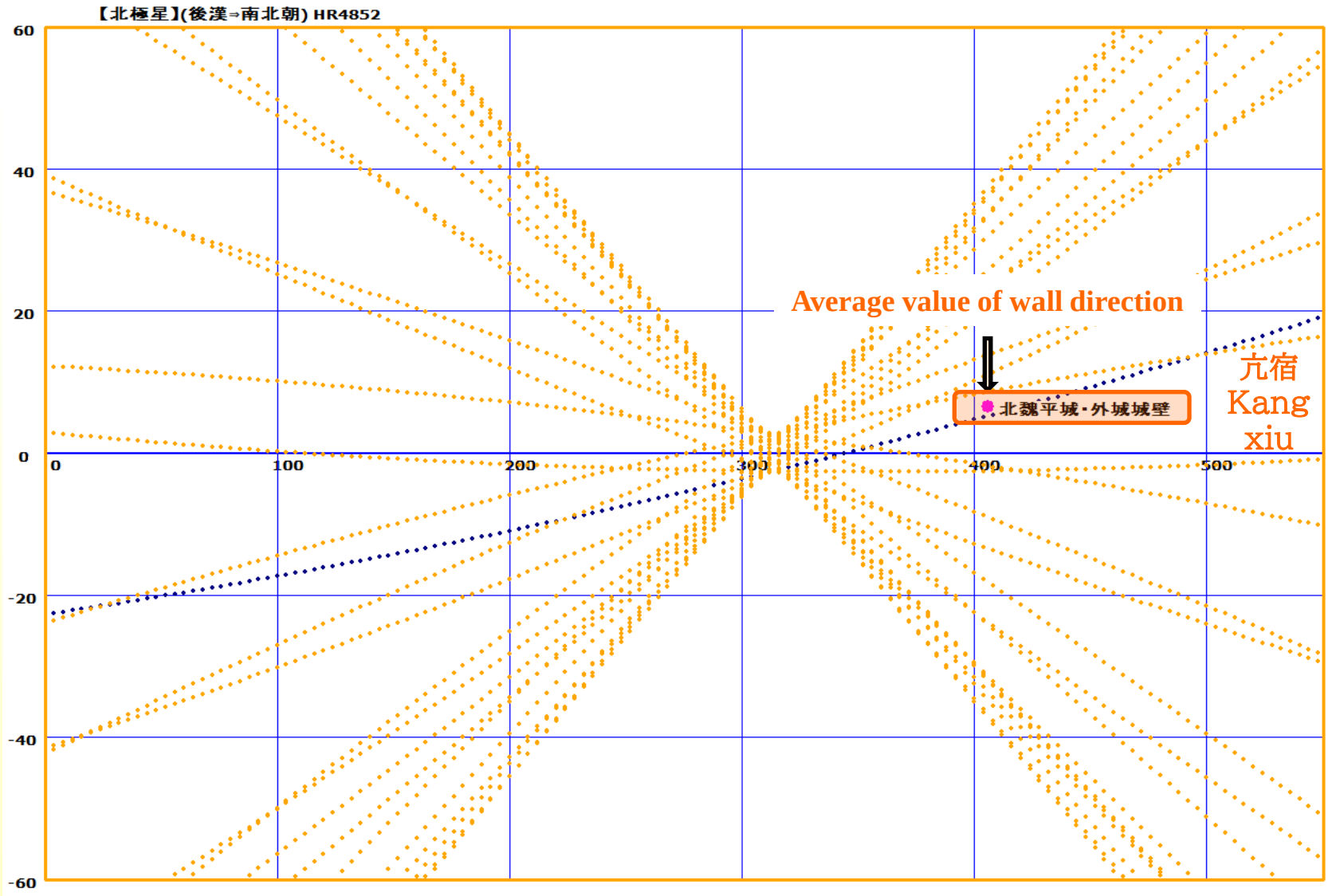
Note: Position at AD300

Northern Wei, Pingcheng (Ming, Datong Castle)

- Datong Castle, located in the northern part of Shanxi Province, was called Datong Prefecture in the Ming Dynasty.
- The walls that still remain today were built from the fifth year of Hongwu (1372) on the basis of ancient walls (Northern Wei, Tang dynasty), starting with the outer wall of Pingcheng, the capital of the Northern Wei Dynasty.
  - ➢ In 398, Emperor of Northern Wei established Heicheng as the capital, and in 406 he built a square outer wall south of castle.
  - ➢ The direction is 6.5 minutes westward on average.



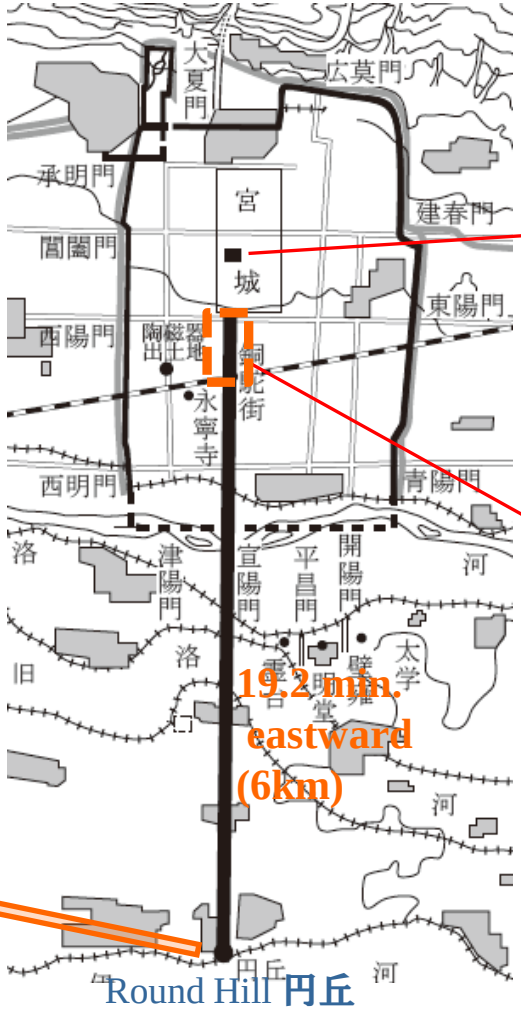
Azimuth line by Pole star (HR4852) and direction of the ruins



【Latitude：40.09° (Datong)】

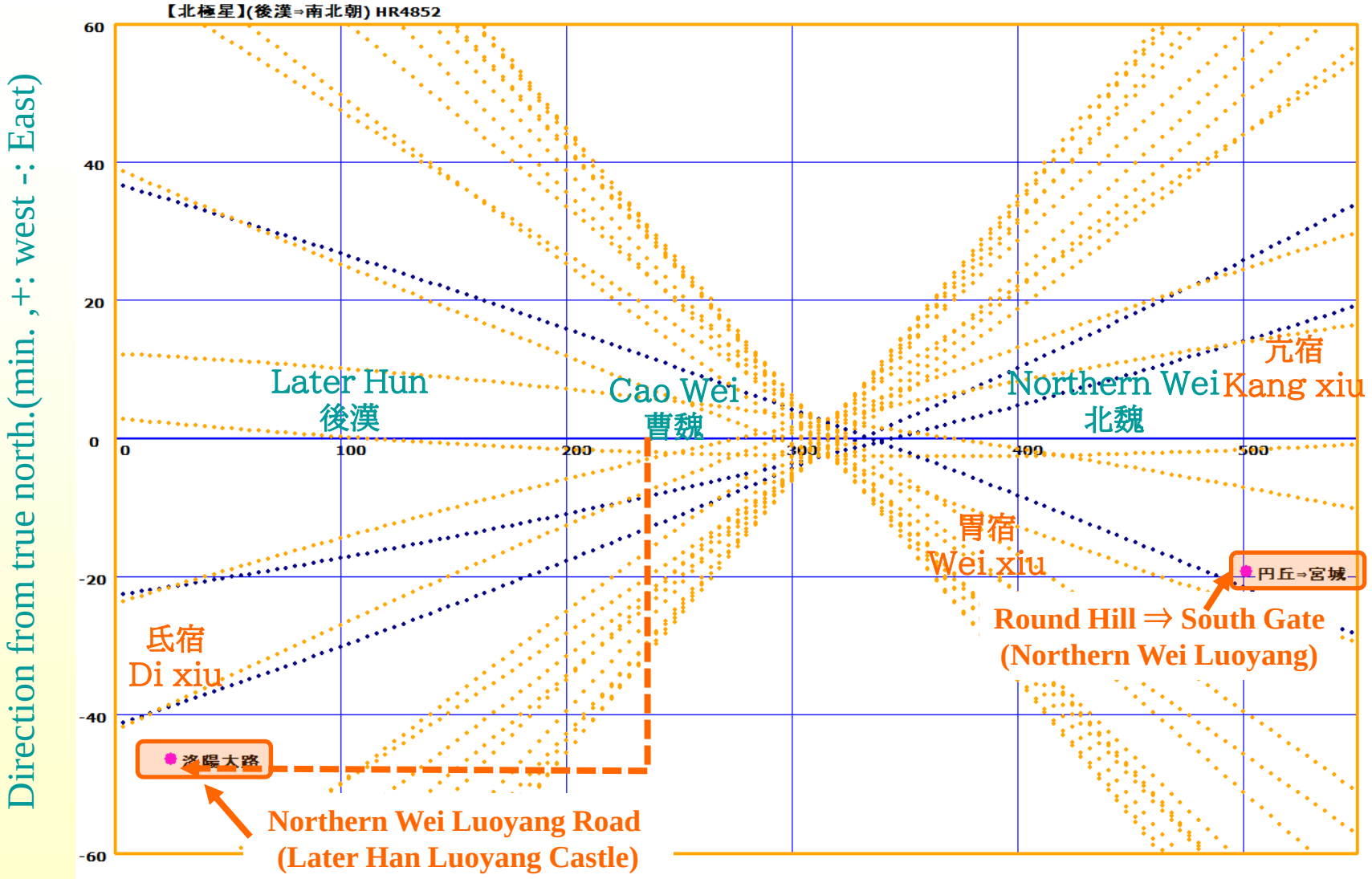
Northern Wei Luoyang Capital castle

- Moved the capital to Luoyang in 493, and built a round hill in 501.
  - The direction from castle to round hill 19.2min east.
  - The main street restored is 46.4 min. eastward.



【銭国祥 「漢魏洛陽城の北魏宮城中枢南部の共同調査」】

Azimuth line by Pole star (HR4852) and direction of the ruins



【緯度設定:34.75° (洛陽)】

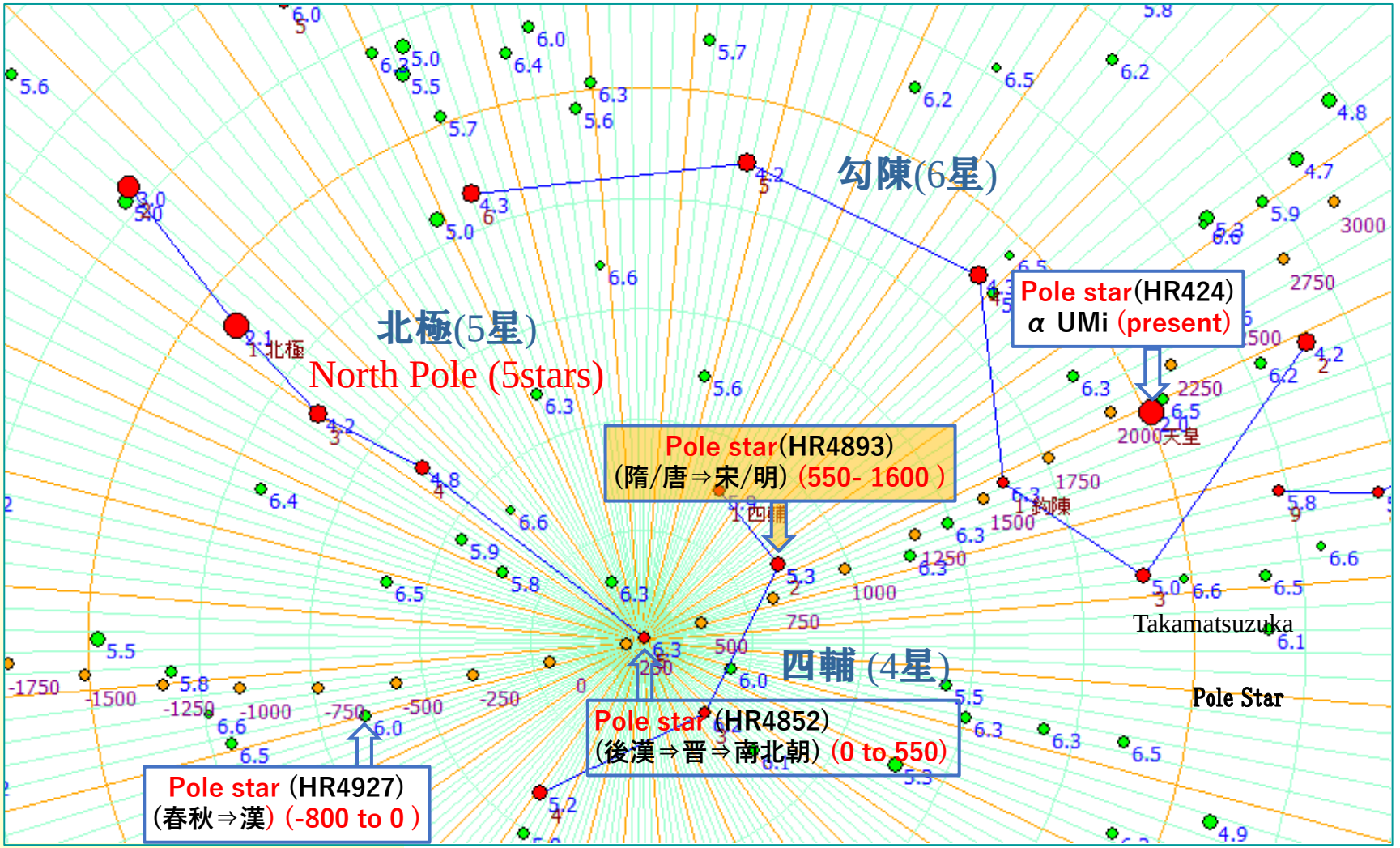
Northern Wei Luoyang Castle(from North)

True North

【http://wap.art.ifeng.com/?app=system&controller=artmobile&action=content&contentid=3508069】

Ruins from the Later Han to the Northern and Southern Dynasties :Pole Star(HR4893)

Chinese constellations based on the identification of the original map of the Jin dynasty (created in early Tang Dynasty).



Note: Position at AD300

Sui/Daxing castle, Tang/Chang'an castle and Ming/Xi'an castle

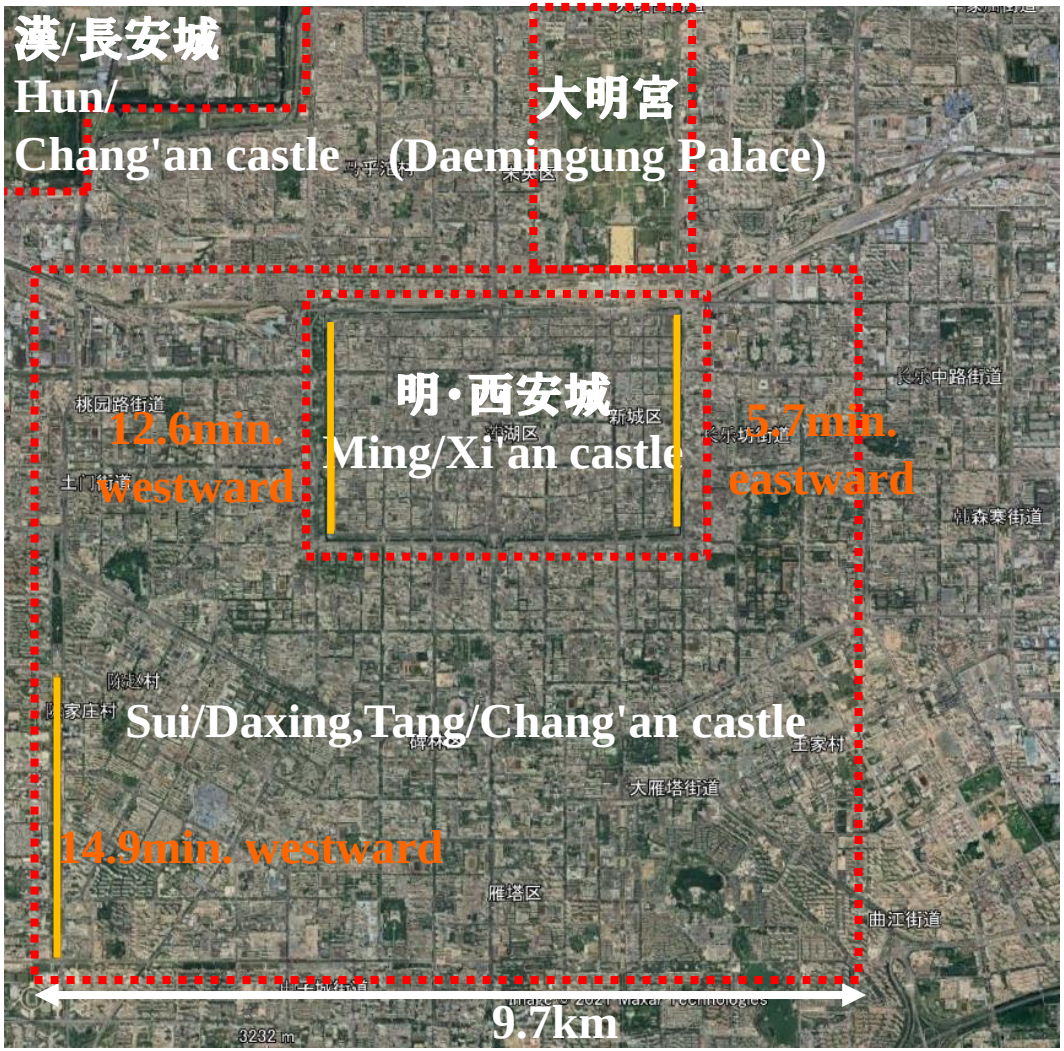
- In 582 AD, Yang Jian of the Sui Dynasty built Daxing Castle to the southeast of Castle of the Han dynasty.
- Castle is 8.6km north to south and 9.7km east to west.
- The southwestern part of the Xi'an Castle Wall was constructed on top of the Sui and Tang Castle Walls.

➢ Measurement results

Chang'an's West wall
:14.9 min. westwards

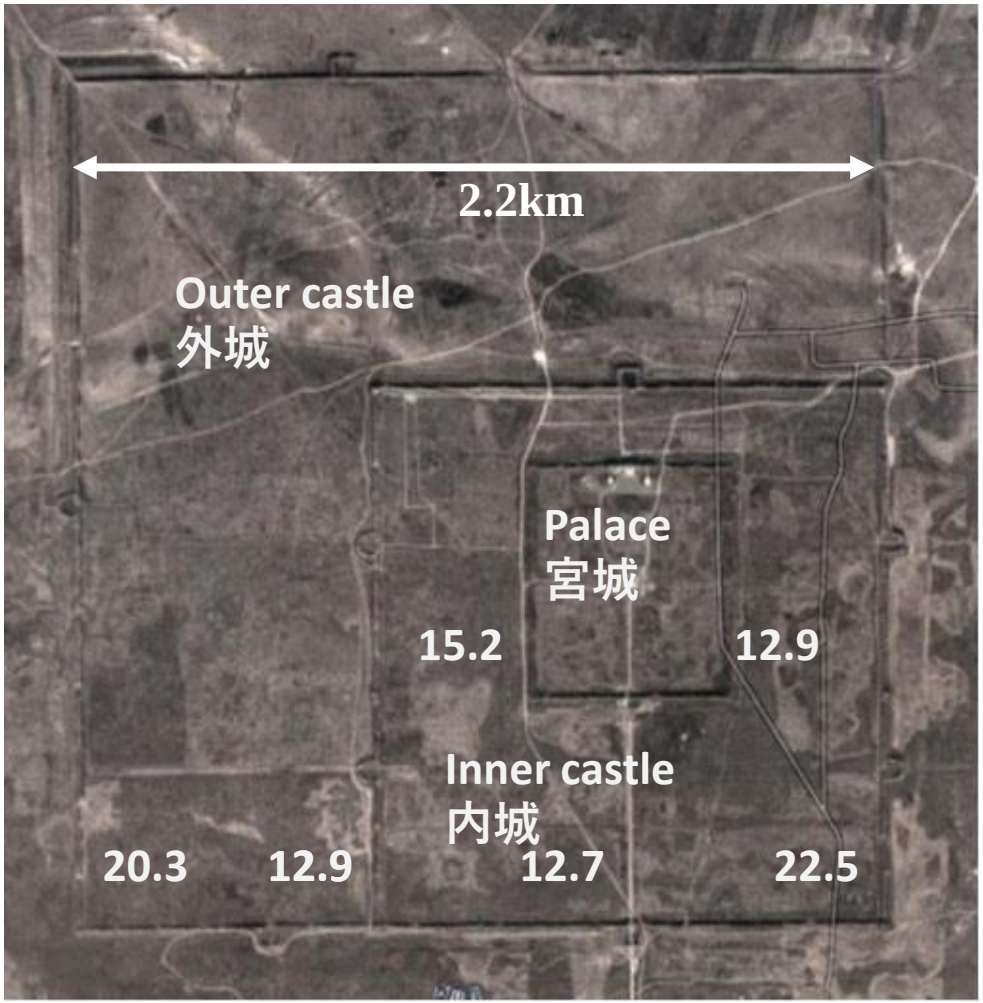
Xi'an's West wall
:12.6 min. westward

Xi'an's Eest wall
: 5.7 min. eastward



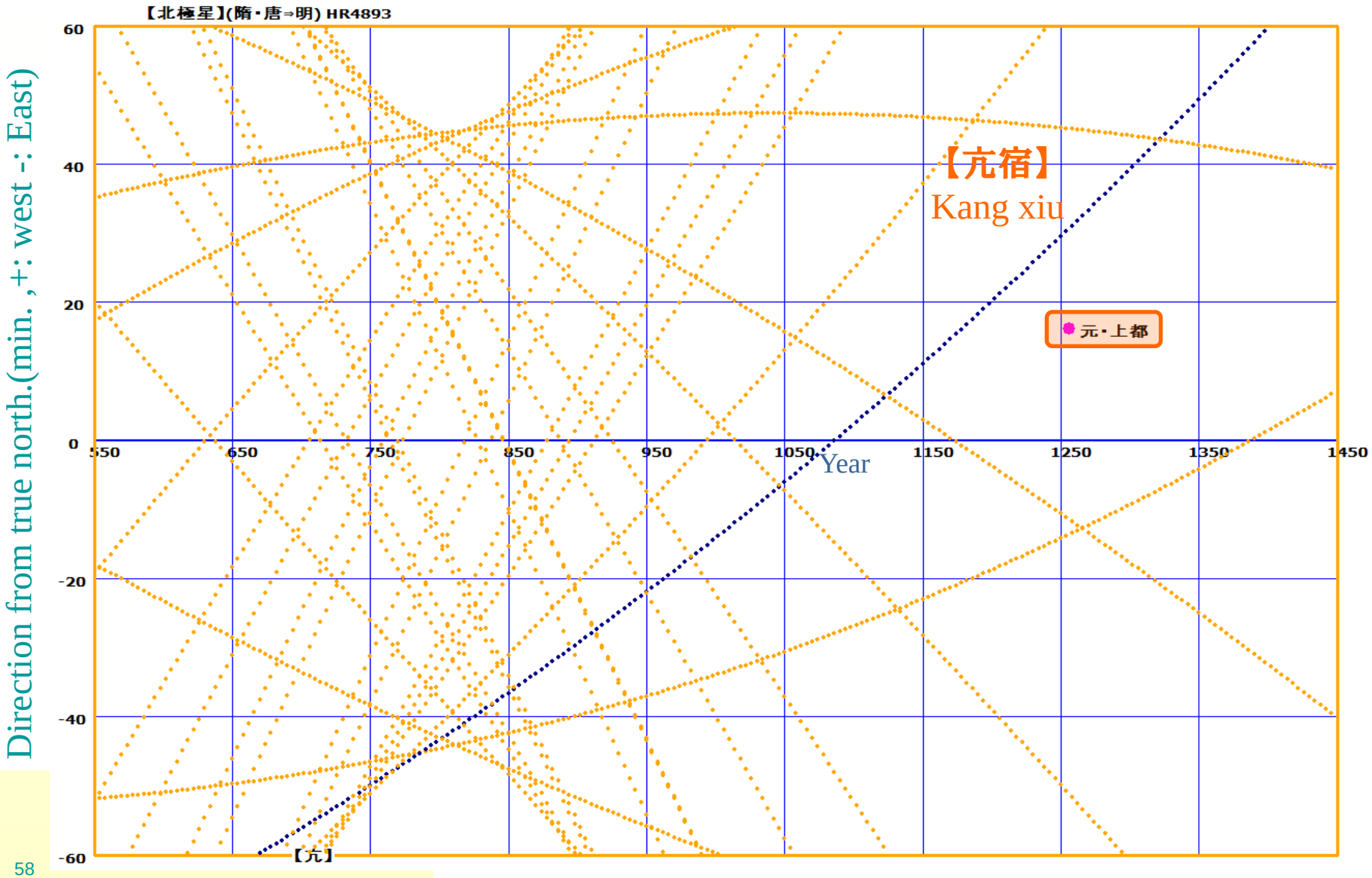
Mongol Empire (Yuan) Shangdu Castle (Measured by the modern Pole Star (αUMi))

- Yuan Shangdu was built in 1256, 270 km north of Beijing, by Kublai of the Mongol Empire under the command of Liu Bing Zhong. The outer castle was added later.。
- Marco Polo stayed there around 1271. He named it Xanadu (meaning modern day paradise).
  - The average direction is 16.1±3.9 minutes westward.
  - 30.8 min. westward by HR4893 with Kang xiu.
  - 15.8 min. westward by the modern Pole Star (αUMi) with Kui xiu. It is almost the same.



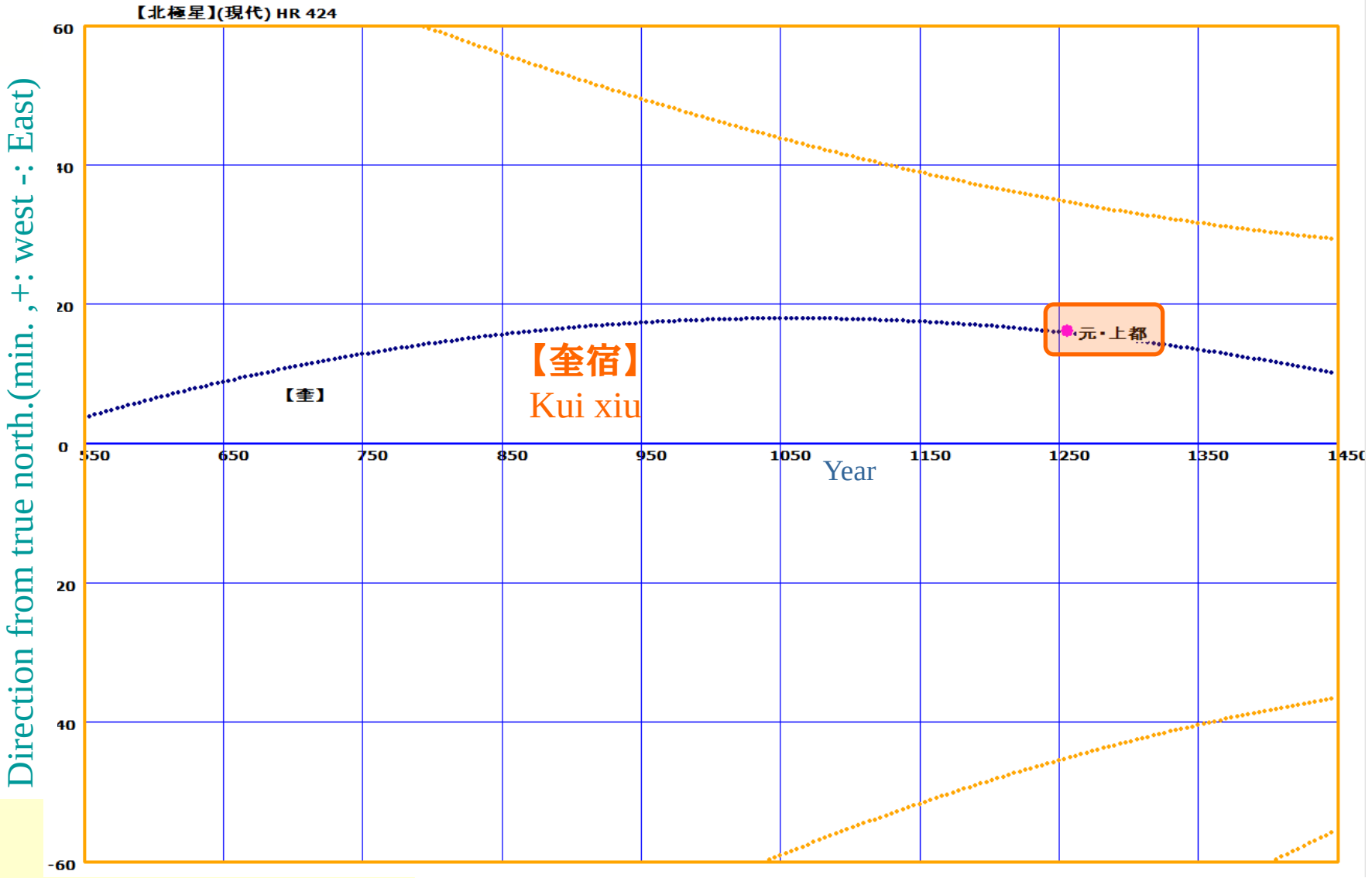
数字は方位(西偏，単位：分)

Azimuth line by Pole star (HR4893) and direction of the Yuan Shangdu Castle



【Latitude：42.37° (Shangdu)】

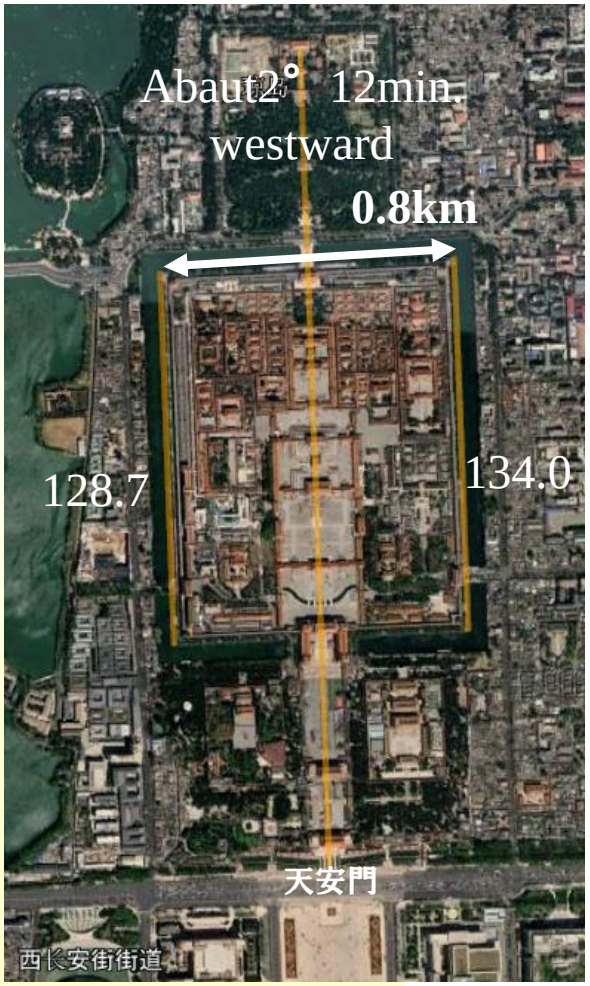
Azimuth line by Pole star (HR424, α UMi) and direction of the Yuan Shangdu Castle

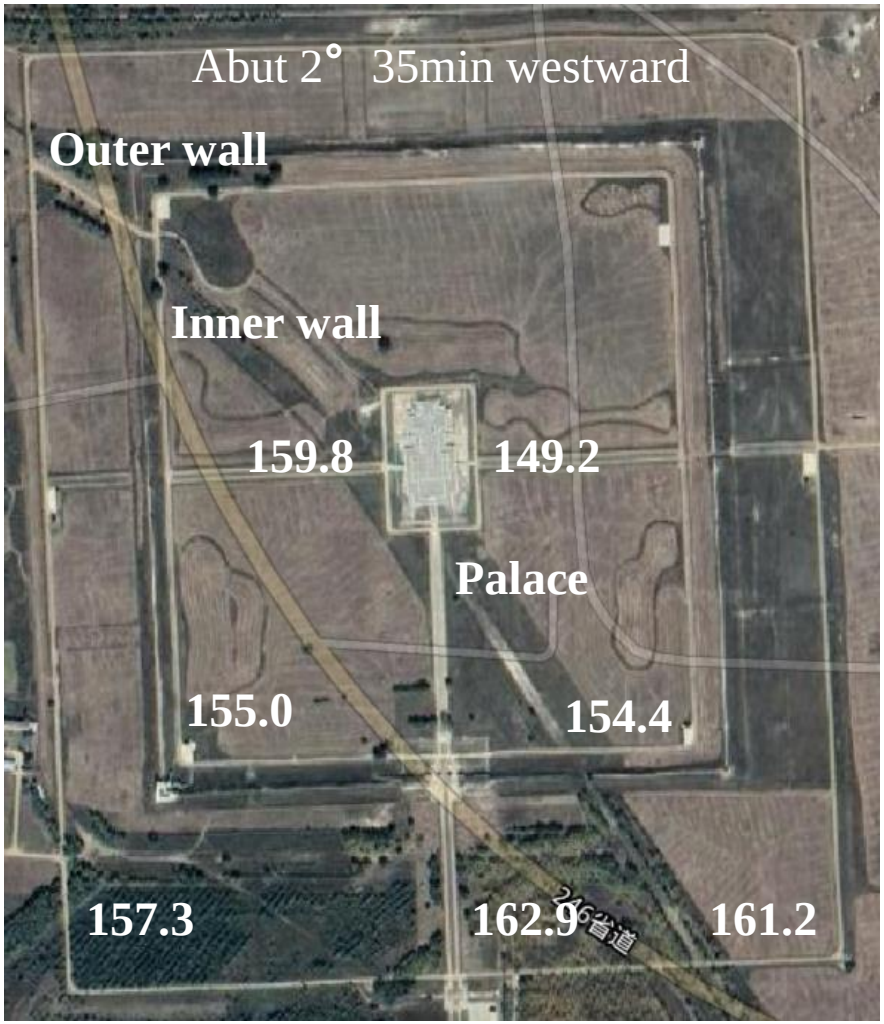


【Latitude：42.37° (Shangdu)】

The direction of Yuan Dadu and Zhongdu

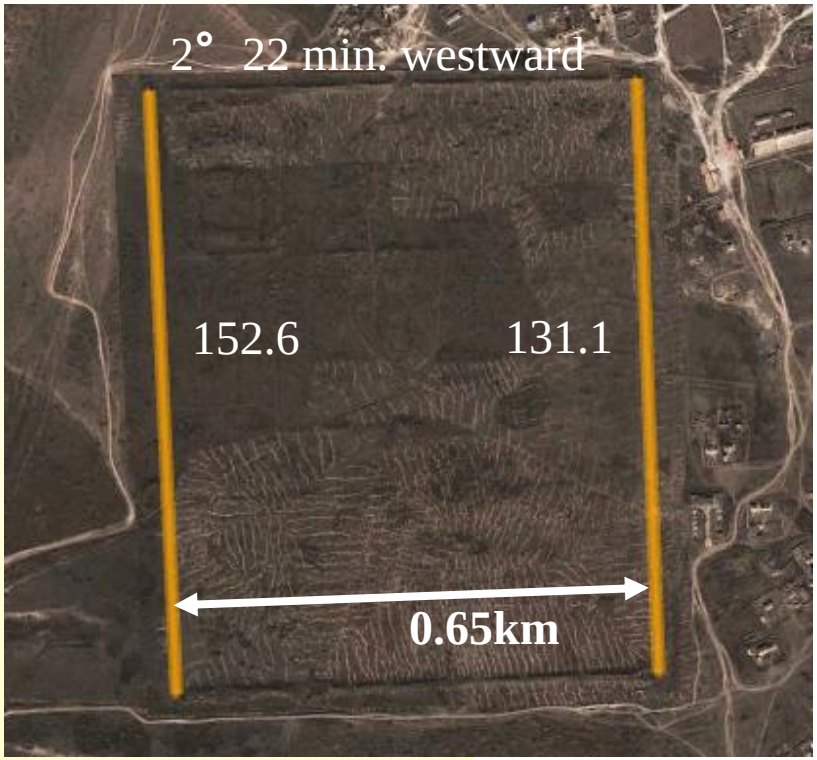
- Beijing was called Dadu (built in 1267) in the Yuan Dynasty.
- Yuan Zhongdu was built by Wuzong in 1307, about 210 km northwest of Beijing.

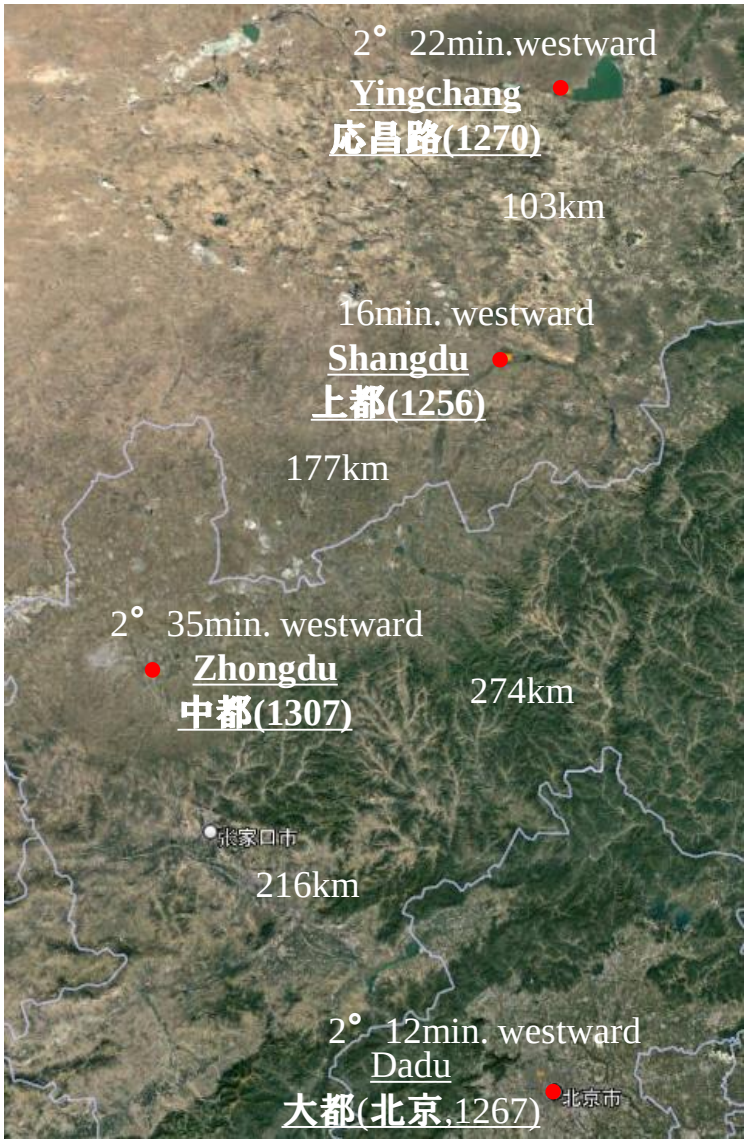




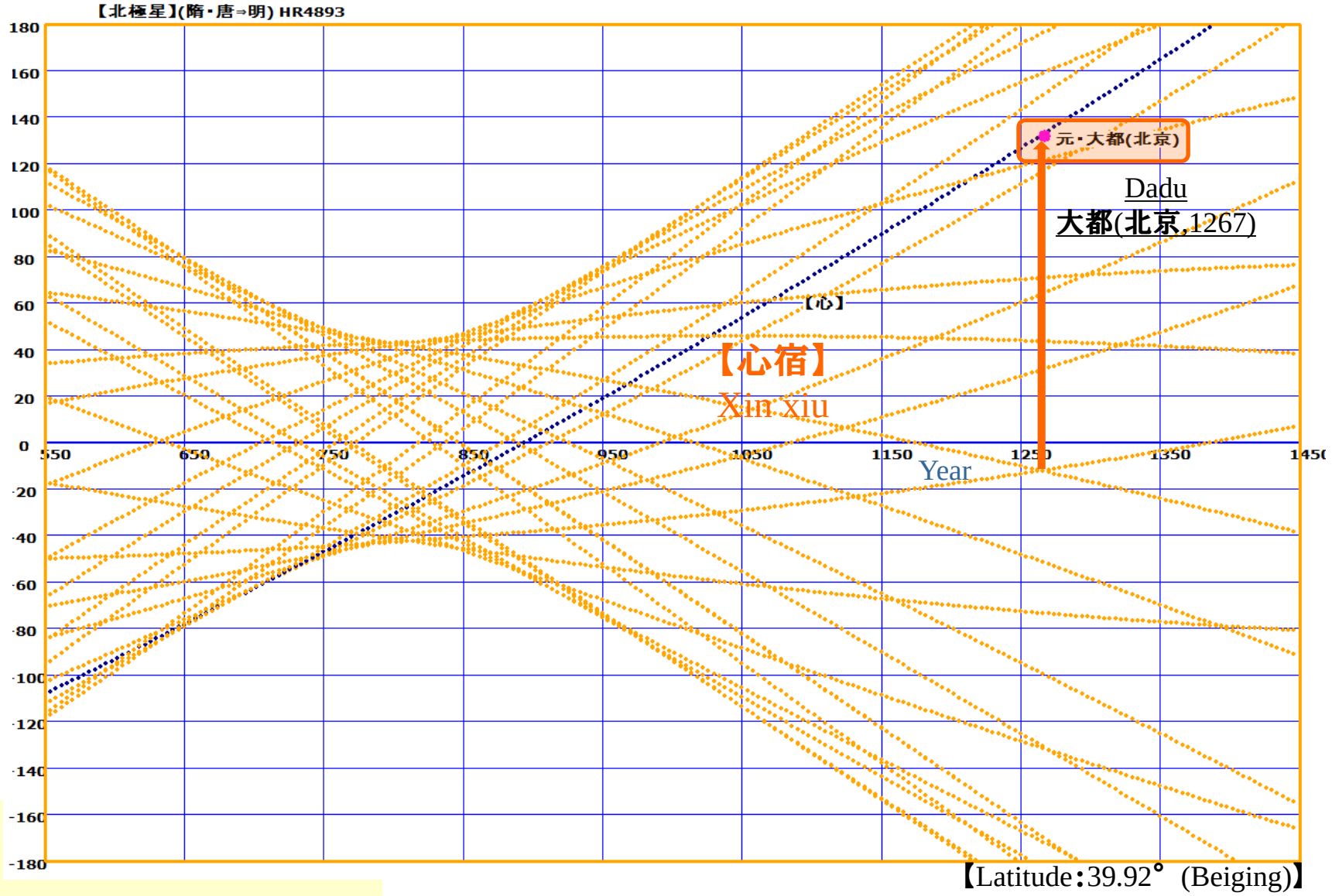
Direction of Yingchang Castle and positional relation of castles

- Yingchang Castle was built around 1270 on the shores of Dalai Noor Lake, about 100km north of Shangdu.



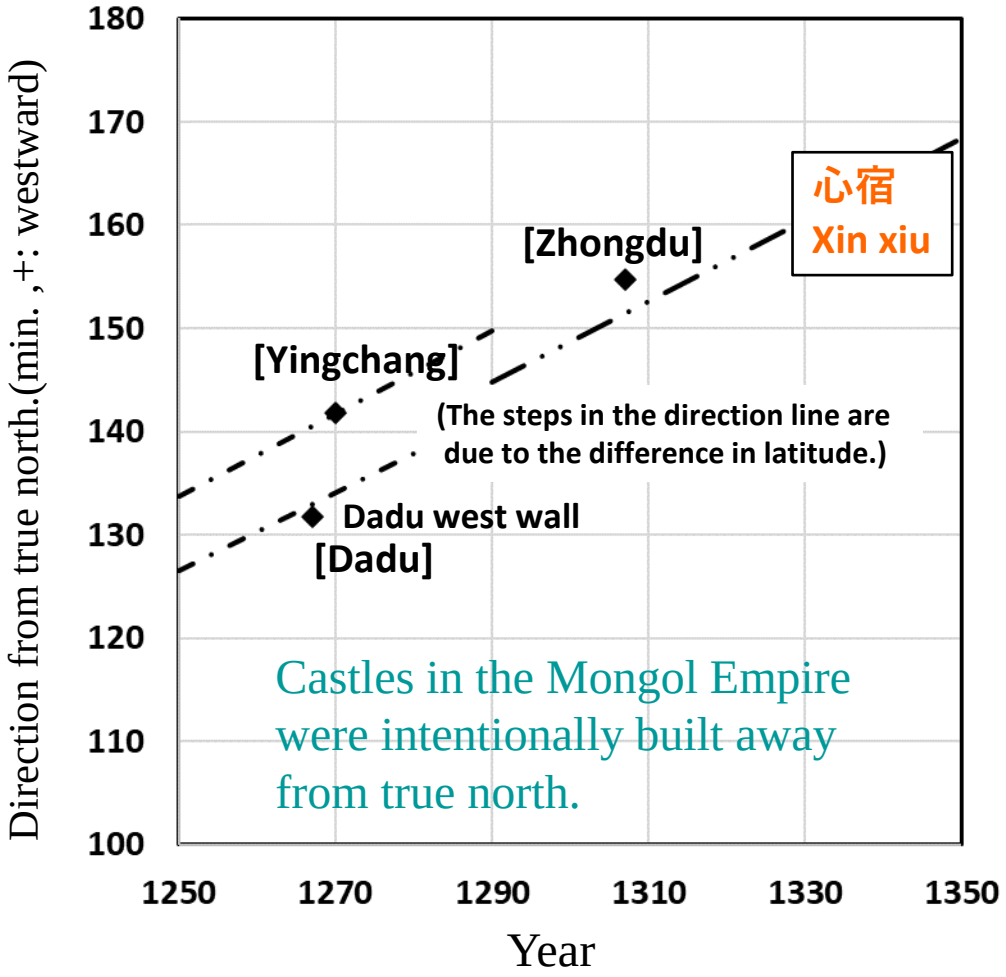


Azimuth line by Pole star (HR4893, α UMi) and direction of the Yuan Dadu Castle

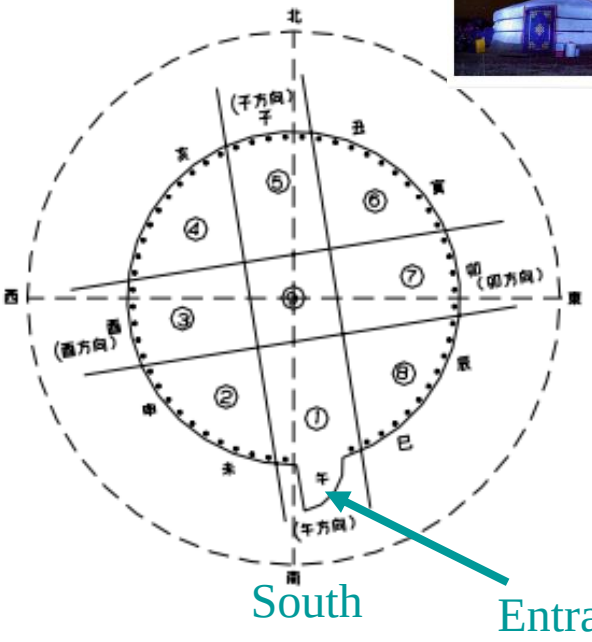


Orientation of the capital castles of the Mongol Empire

Direction of castles and calculated value (HR4893)



Orientation of Ger(11-16c)



【海日汗「ゲルの方位についての研究」(2004)より】

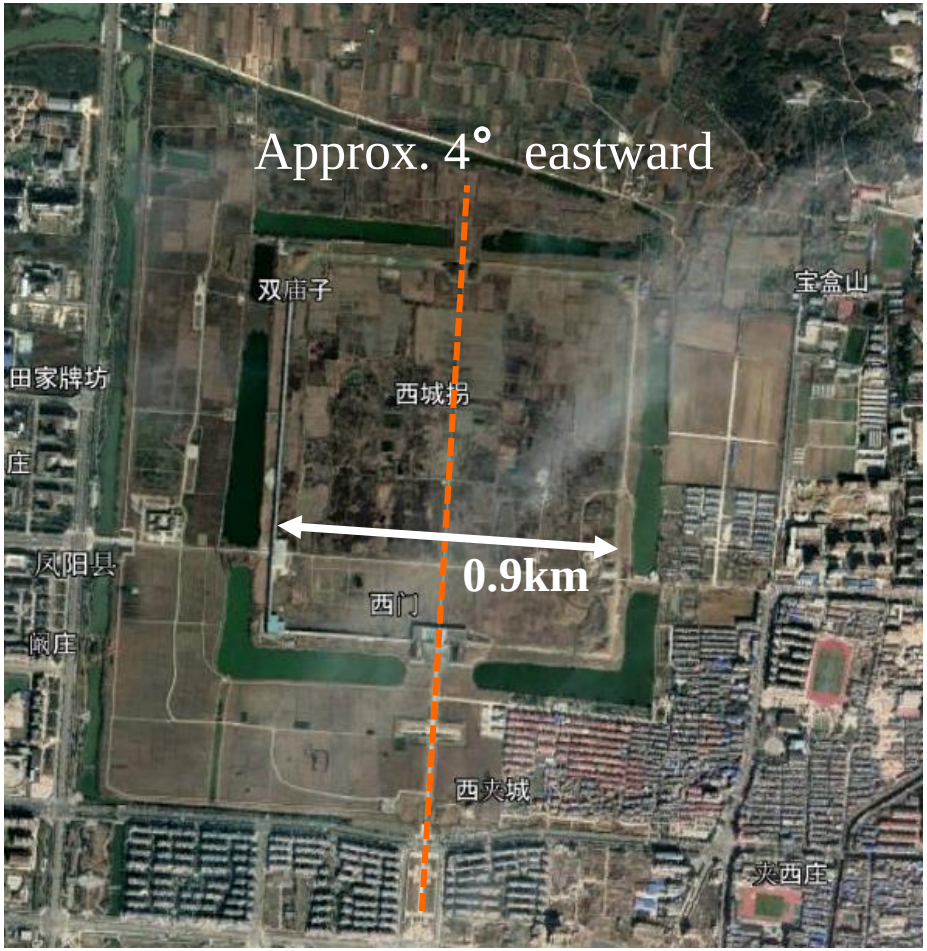
The direction of the capital castle of the Mongol Empire (Yuan) is unique to Mongolia

The end of True north measurement by Pole star (Ming dynasty Zhongdu)

- Zhongdu, 150 km northwest of Nanjing, construction started in 1369.
- Six years later, construction was stopped and Nanjing became the official capital.
- The direction is deviated to the east by about 4° .
  ⇒not the Pole Star, but the compass is used for measurement.

(approx. 5.5° eastward of true north at 120° east longitude)

Ming/Zhongdu(32.88° N 117.54° E)



Summary of Measured direction and Calculated direction of Historic Sites in China

Summary of Measured and Calculated direction of Historic Sites in China

史跡	測定位置	緯度(度)	経度(度)	方位(分)	距離(km)
趙王城	西城西城壁(南)	36.568541	114.427380		
	同　(北)	36.581473	114.427239	30.2	1.4
	西城東城壁(南)	36.568937	114.442748		
	同　(北)	36.581640	114.442883	-29.5	1.4
	東城東城壁(南)	36.568575	114.452232		
	同　(北)	36.571522	114.452272	-37.6	0.3
	北城西城壁(南)	36.581616	114.437289		
	同　(北)	36.586745	114.437361	-38.9	0.6
秦始皇帝陵墓	重点	34.381307	109.253923		
前漢長安	子午谷(西山尾根)	34.038333	108.875994		
	長安城安門	34.293000	108.879694	-41.5	28.3
	長安城安門	34.293000	108.879694		
	五方基壇(中央)	34.709781	108.886627	-47.2	46.2
北魏平城(明大同)	西城壁(南)	40.084995	113.284952		
	同　(北)	40.100766	113.284872	13.4	1.8
	東城壁(南)	40.084586	113.305666		
	同　(北)	40.100461	113.305669	-0.5	1.8
北魏洛陽城	円丘	34.672717	112.622125		
	宮城閶闔門(南門)	34.726608	112.622487	-19.1	6.0
	南門大路南端中心	34.721467	112.622403		
	宮城閶闔門(南門)	34.726608	112.622487	-46.4	0.6
隋大興城(長安城)	城壁跡西側道(南)	34.206909	108.884225		
	同　(北)	34.238038	108.884070	14.2	3.5
	城壁跡東側道(南)	34.206909	108.884534		
	同　(北)	34.238038	108.884364	15.6	3.5
隋皇城跡(明西安)	西城壁(南)	34.254058	108.920656		
	同　(北)	34.276969	108.920555	12.6	2.5
明西安	東城壁(南)	34.254562	108.966368		
	同　(北)	34.277529	108.966414	-5.7	2.5
元上都	外城西城壁(南)	42.349908	116.166702		
	同　(北)	42.369621	116.166545	20.3	2.2
	外城東城壁(南)	42.349999	116.193540		
	同　(北)	42.369808	116.193365	22.5	2.2
	内城西城壁(南)	42.349917	116.176676		
	同　(北)	42.362523	116.176612	12.9	1.4
	王宮西城壁(南)	42.355322	116.181808		
	同　(北)	42.360697	116.181776	15.2	0.6
	王宮東城壁(南)	42.355359	116.188355		
	同　(北)	42.360706	116.188328	12.9	0.6
	中軸線城壁(南)	42.349983	116.185115		
	同　(北)	42.360655	116.185062	12.7	1.2
元中都	内城西城壁(南)	41.289913	114.618152		
	同　(北)	41.295430	114.617822	155.0	0.6
	内城東城壁(南)	41.290180	114.624684		
	同　(北)	41.295584	114.624362	154.4	0.6
元大都(北京)	紫禁城西濠岸(南)	39.912018	116.386351		
	同　(北)	39.921064	116.385911	128.7	1.0
	紫禁城東濠岸(南)	39.912371	116.395617		
	同　(北)	39.921417	116.395159	134.0	1.0
元応昌路城	外城西城壁(南)	43.250952	116.458185		
	同　(北)	43.258259	116.457741	152.6	0.8
	外城東城壁(南)	43.251197	116.466239		
	同　(北)	43.258422	116.465862	131.1	0.8

Comparison of Measured and Calculated Directions of Historic Sites in China

史跡	測定位置	北極星	定星	推定年	測定値(分)	計算値(分)	差(分)
趙王城	西城西城壁	HR4927	12室宿	-385	30.2	36.4	-6.2
趙王城	西城東城壁	HR4927	26翼宿	-385	-29.5	-38.4	8.9
趙王城	東城東城壁	HR4927	26翼宿	-385	-37.6	-38.4	0.8
趙王城	北城西城壁	HR4927	26翼宿	-385	-38.9	-38.4	-0.5
秦始皇帝陵	中軸線	HR4927	26翼宿	-220	*1) -84.0	-84.7	0.7
前漢長安	子午谷(西山)⇒安門	HR4927	27軫宿	-201	-41.5	-39.6	-1.9
前漢長安	安門⇒五方基壇	HR4927	27軫宿	-201	*1) -46.9	-39.6	-7.3
前漢長安	長安城(安門中軸)	HR4927	13壁宿	-201	*1) 36.0	39.9	-3.9
前漢長安	長安城(城門間)	HR4927	15婁宿	-193	*1) -30.0	-29.7	-0.3
前漢長安	五方基壇	HR4927	15婁宿	-193	*1) -27.2	-29.7	2.5
前漢長安	高祖長陵/皇后墓	HR4927	0角宿	-193	*1) 13.3	10.9	2.4
前漢長安	陽陵(中軸)	HR4927	14奎宿	-155	*1) 19.2	20.8	-1.6
北魏洛陽城(漢代)	南門大路	HR4852	2氐宿	25	-46.4	-38.8	-7.6
北魏平城(明大同)	外城々壁平均値	HR4852	1亢宿	406	6.5	5.7	0.8
北魏洛陽城	円丘⇒宮城(中軸線)	HR4852	16胃宿	501	-19.2	-21.8	2.6
隋大興城(長安城)	外城西城壁跡(平均)	HR4893	26翼宿	582	14.9	11.4	3.5
隋大興城(明西安)	皇城西城壁跡	HR4893	26翼宿	582	12.6	11.4	1.2
明西安	東城壁	HR4893	0角宿	1370	-5.7	-2.2	-3.5
元上都	平均値(6箇所)	HR424	14奎宿	1256	16.1	15.8	0.3
元大都(北京)	外城西城壁	HR4893	4心宿	1267	*1) 131.7	133.0	1.3
元応昌路城	外城々壁平均値	HR4893	4心宿	1270	141.9	141.7	0.2
元中都	内城々壁平均値	HR4893	4心宿	1307	154.7	151.5	3.2
						*2) 平均	-0.2

*1: Value quoted from the papers.
The deflection of the central axis of the Mausoleum of the First Emperor is based on Masahiro Etaya et al. (2014) p.133. The measured values forAn gate of Chang'an to Five Altars, Five Altars and Changling are from Huang Xiaofen (2006) p.49, 44, 46, respectively. Actual measurements in Former Han Chang'an Castle are based on Takao Uno (2010) p.72. The value of Yangrling is based on Takao Uno (2010) p.69. The measured value of Dadu West Wall (remaining part) is based on Takao Uno (2008) p.185.*2: Average is -0.2±3.8(σ) minutes

Note to left table:
Those with values for direction and distance are the calculated values of the direction and distance as seen from the place in the column above. A positive direction deviates to the west from true north, and a negative direction deviates to the east. The measured position of An Gate in Chang'an Castle is based on Huang Xiaofen (2006) p.44. Others are measurements around February 2021 by the author's Google Earth Pro. Only the Xi'an Castle Wall is based on the July 30, 2021 version of the image. It may change due to the update of the image used by Google.

6. Verification of the orientation of ancient remains in Japan

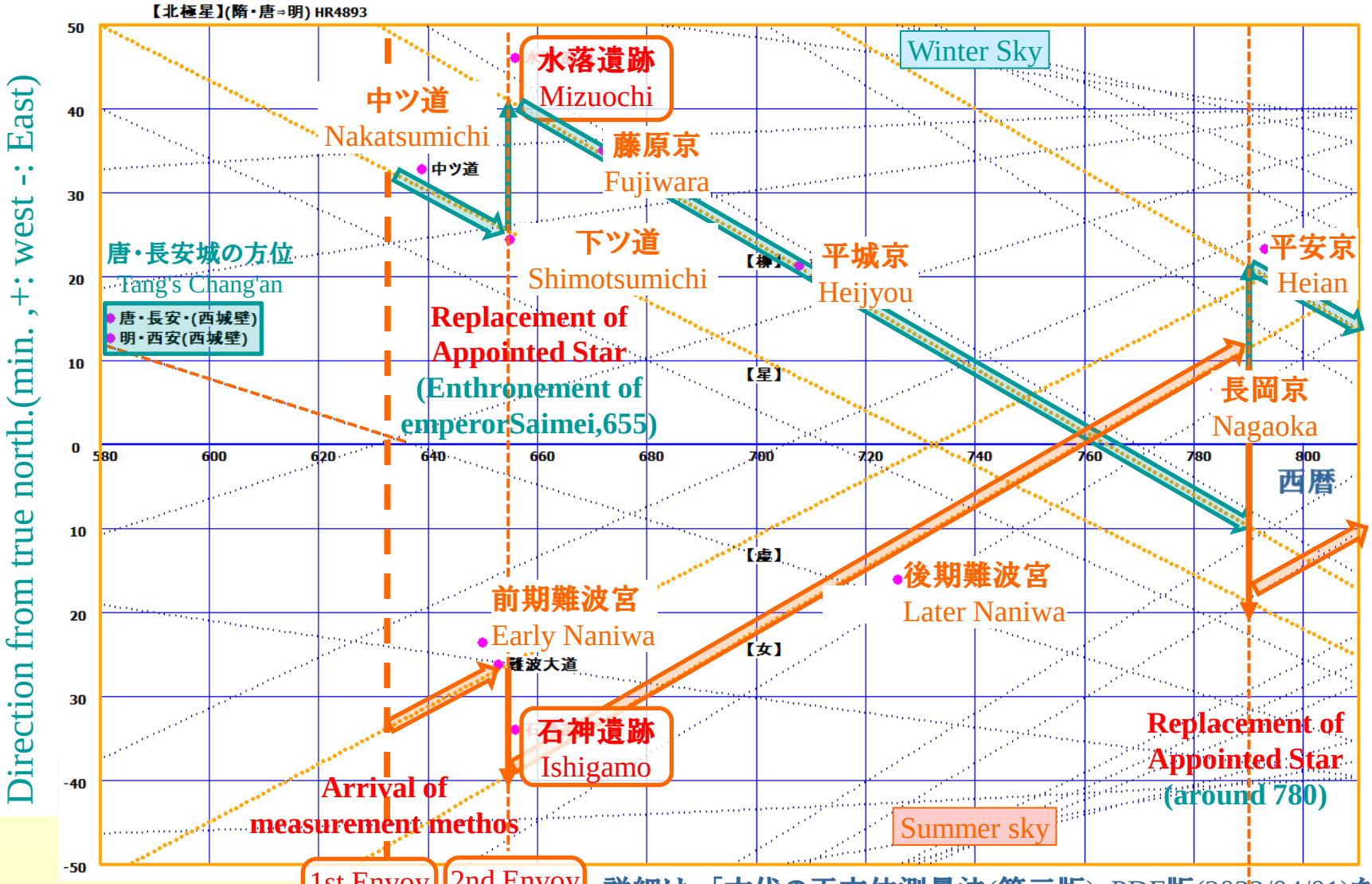
Directions of Japanese capitals and main roads

Ruins	Year	Rectangular coordinates	Correction	Direction from TN		Sources
(参)太子道(筋違道)	?			西	約20度	奈文研(2007)p.196
(参)法隆寺(若草伽藍跡)	607			西	約20度	奈文研(2007)p.196
飛鳥岡本宮[*5]	630			西	約20度	林部 均(2008)p.37
百済宮	639			ー	(正方位)	百済寺より筆者推定
大和・中ツ道	(639)	26分31秒	6分12秒	西	32分43秒	本書・第三章5項参照
飛鳥板蓋宮[*5]	643			ー	(正方位)	林部 均(2008)p.37
前期難波宮(中軸線)	650	ー39分56秒	16分17秒	東	23分39秒	李陽浩(2005)p.93
難波大道中軸線	(653)[*6]	ー42分39秒	16分17秒	東	26分22秒	李陽浩(2005)p.94
後飛鳥岡本宮	655			ー	(正方位)	林部 均(2008)p.96
大和・下ツ道(A区間)	(653)[*6]	15分36秒	6分56秒	西	22分32秒	本書・第四章2項参照
大和・下ツ道(B区間)	(655)	35分51秒	6分56秒	西	42分47秒	本書・第四章2項参照
大和・下ツ道(C区間)	(656)			東	40分	本書・第四章2項参照
横大路	(653)[*6]			西	28分	本書・第四章5項参照
飛鳥浄御原宮[*5]	672			ー	(正方位)	林部 均(2008)p.122
藤原京(条坊最適方格)	672[*7]	28分21秒	6分32秒	西	34分53秒	入倉徳裕(2013)p.180
平城京(条坊最適方格)	708	14分15秒	6分56秒	西	21分11秒	入倉徳裕(2013)p.180
大宰府政庁Ⅱ期(中軸線)	(713)[*8]	ー34分24秒	16分04秒	東	18分20秒	井上信正(2009)p.19
後期難波宮(中軸線)	726	ー32分31秒	16分17秒	東	16分14秒	李陽浩(2005)p.93
長岡京(条坊最適方格)	784	ー3分44秒	10分12秒	西	6分28秒	岩松保(1996)p.21
平安京(条坊最適方格)	793	14分23秒	8分52秒	西	23分15秒	辻純一(1994)p.115
平安京白河街区(今朱雀)	1075	ー49分30秒	7分38秒	東	41分52秒	濱崎一志(1994)p.130

Ruins of True North Direction

Omi Otsunomiya (667, about 1.5 degrees to the west) and Kunikyo (740, about 1 degree to the west), which have large swings, were excluded.

Azimuth line by Pole star (HR4893) and direction of the ruins of Japan



詳細は、「古代の正方位測量法(第三版)」PDF版(2022/04/01)を参照。

【Latitude：34.75° (Nara/Kyoto)】

Estimation of dating from the orientation of historic remains

Differences in orientation and date of historic sites and remains

Historic sites	Year	Direction	Xiu	Est. Direction (m)	Diff.(m)	Estimated year	Diff.(Y)
(大和・中ツ道)	(639)	32分43秒	星宿	30.44	2.3	632	7
前期難波宮(中軸線)	650	－23分39秒	虚宿	-27.75	4.1	662	-12
難波大道中軸線	(653)	－26分22秒	虚宿	-26.73	0.4	654	-1
大和・下ツ道(A区間)	(653)	22分32秒	星宿	25.84	-3.3	662	-9
大和・下ツ道(B区間)	(655)	42分47秒	柳宿	40.77	2.0	649	6
大和・下ツ道(C区間)	(656)	－40分	女宿	-38.83	-1.2	653	3
大和・横大路	(653)	28分	星宿	25.84	-3.3	646	7
藤原京(条坊最適方格)	672	34分53秒	柳宿	34.38	0.5	671	1
平城京(条坊最適方格)	708	21分11秒	柳宿	20.86	0.3	707	1
大宰府政庁Ⅱ期(中軸線)	(713)	－18分20秒	女宿	-17.24	-1.1	710	3
後期難波宮(中軸線)	726	－16分14秒	女宿	-12.35	-3.9	716	10
長岡京(条坊最適方格)	784	6分28秒	女宿	9.35	-2.9	777	7
平安京(条坊最適方格)	793	23分15秒	参宿	19.95	3.3	784	9
平安京白河街区(今朱雀)*1	1075	－41分52秒	昴宿	-40.43	-1.4	1080	-5
			平均	-0.3±2.5(σ)		1.9±6.5(σ)	

The error (σ) between the actual date of the site and the estimated date based on the orientation is about ±7 years.

⇒**It is possible to estimate the date based on the orientation of the remains.**

However, since there are multiple date in one direction, it is necessary to narrow down the estimated date.

A quick reference chart of current directions and estimated years (630-829, unit: minutes)

西暦	虚宿	女宿	星宿	柳宿
630	-34.6		33.3	
631	-34.3		32.9	
632	-33.9		32.6	
633	-33.6		32.3	
634	-33.3		31.9	
635	-32.9		31.6	
636	-32.6		31.3	
637	-32.2		31.0	
638	-31.9		30.6	
639	-31.5		30.3	
640	-31.2		30.0	
641	-30.9		29.6	
642	-30.5		29.3	
643	-30.2		29.0	
644	-29.8		28.7	
645	-29.5		28.3	
646	-29.1		28.0	
647	-28.8		27.7	
648	-28.5		27.4	
649	-28.1		27.0	42.9
650	-27.8	-41.2	26.7	42.5
651	-27.4	-40.8	26.4	42.1
652	-27.1	-40.4	26.0	41.8
653	-26.8	-40.0	25.7	41.4
654	-26.4	-39.6	25.4	41.0
655	-26.1	-39.3	25.1	40.6
656	-25.7	-38.9	24.7	40.2
657	-25.4	-38.5	24.4	39.9
658	-25.1	-38.1	24.1	39.5
659	-24.7	-37.7	23.7	39.1
660	-24.4	-37.3	23.4	38.7
661	-24.0	-37.0	23.1	38.4
662	-23.7	-36.6	22.8	38.0
663	-23.4	-36.2	22.4	37.6

西暦	虚宿	女宿	柳宿
663	-23.4	-36.2	37.6
664	-23.0	-35.8	37.2
665	-22.7	-35.4	36.9
666	-22.3	-35.1	36.5
667	-22.0	-34.7	36.1
668	-21.7	-34.3	35.7
669	-21.3	-33.9	35.4
670	-21.0	-33.5	35.0
671	-20.6	-33.2	34.6
672	-20.3	-32.8	34.2
673	-20.0	-32.4	33.9
674	-19.6	-32.0	33.5
675	-19.3	-31.7	33.1
676	-18.9	-31.3	32.7
677	-18.6	-30.9	32.4
678	-18.3	-30.5	32.0
679	-17.9	-30.1	31.6
680	-17.6	-29.8	31.2
681	-17.3	-29.4	30.8
682	-16.9	-29.0	30.5
683	-16.6	-28.6	30.1
684	-16.2	-28.2	29.7
685	-15.9	-27.9	29.3
686	-15.6	-27.5	29.0
687	-15.2	-27.1	28.6
688	-14.9	-26.7	28.2
689	-14.6	-26.3	27.8
690	-14.2	-26.0	27.5
691	-13.9	-25.6	27.1
692	-13.5	-25.2	26.7
693	-13.2	-24.8	26.3
694	-12.9	-24.5	26.0
695	-12.5	-24.1	25.6
696	-12.2	-23.7	25.2

西暦	女宿	柳宿
696	-23.7	25.2
697	-23.3	24.8
698	-22.9	24.5
699	-22.6	24.1
700	-22.2	23.7
701	-21.8	23.3
702	-21.4	23.0
703	-21.1	22.6
704	-20.7	22.2
705	-20.3	21.8
706	-19.9	21.5
707	-19.5	21.1
708	-19.2	20.7
709	-18.8	20.3
710	-18.4	20.0
711	-18.0	19.6
712	-17.7	19.2
713	-17.3	18.8
714	-16.9	18.5
715	-16.5	18.1
716	-16.1	17.7
717	-15.8	17.3
718	-15.4	17.0
719	-15.0	16.6
720	-14.6	16.2
721	-14.3	15.8
722	-13.9	15.5
723	-13.5	15.1
724	-13.1	14.7
725	-12.8	14.3
726	-12.4	14.0
727	-12.0	13.6
728	-11.6	13.2
729	-11.3	12.8

西暦	女宿	柳宿
730	-10.9	12.5
731	-10.5	12.1
732	-10.1	11.7
733	-9.8	11.3
734	-9.4	11.0
735	-9.0	10.6
736	-8.6	10.2
737	-8.2	9.8
738	-7.9	9.5
739	-7.5	9.1
740	-7.1	8.7
741	-6.7	8.3
742	-6.4	8.0
743	-6.0	7.6
744	-5.6	7.2
745	-5.2	6.8
746	-4.9	6.5
747	-4.5	6.1
748	-4.1	5.7
749	-3.8	5.4
750	-3.4	5.0
751	-3.0	4.6
752	-2.6	4.2
753	-2.3	3.9
754	-1.9	3.5
755	-1.5	3.1
756	-1.1	2.7
757	-0.8	2.4
758	-0.4	2.0
759	0.0	1.6
760	0.4	1.2
761	0.7	0.9
762	1.1	0.5
763	1.5	0.1

西暦	箕宿	女宿	参宿	柳宿
763		1.5		0.1
764		1.9		-0.3
765		2.2		-0.6
766		2.6		-1.0
767		3.0		-1.4
768		3.4		-1.8
769		3.7		-2.1
770	-26.2	4.1	28.5	-2.5
771	-25.8	4.5	28.1	-2.9
772	-25.4	4.9	27.7	-3.3
773	-25.0	5.2	27.3	-3.6
774	-24.6	5.6	26.9	-4.0
775	-24.3	6.0	26.6	-4.4
776	-23.9	6.3	26.2	-4.8
777	-23.5	6.7	25.8	-5.1
778	-23.1	7.1	25.4	-5.5
779	-22.7	7.5	25.1	-5.9
780	-22.3	7.8	24.7	-6.2
781	-21.9	8.2	24.3	-6.6
782	-21.5	8.6	23.9	-7.0
783	-21.1	9.0	23.6	-7.4
784	-20.7	9.3	23.2	-7.7
785	-20.3	9.7	22.8	-8.1
786	-19.9	10.1	22.4	-8.5
787	-19.5	10.4	22.1	-8.9
788	-19.2	10.8	21.7	-9.2
789	-18.8	11.2	21.3	-9.6
790	-18.4	11.6	20.9	-10.0
791	-18.0		20.6	
792	-17.6		20.2	
793	-17.2		19.8	
794	-16.8		19.4	
795	-16.4		19.1	
796	-16.0		18.7	

西暦	箕宿	参宿
796	-16.0	18.7
797	-15.6	18.3
798	-15.2	17.9
799	-14.8	17.5
800	-14.4	17.2
801	-14.0	16.8
802	-13.7	16.4
803	-13.3	16.0
804	-12.9	15.7
805	-12.5	15.3
806	-12.1	14.9
807	-11.7	14.5
808	-11.3	14.2
809	-10.9	13.8
810	-10.5	13.4
811	-10.1	13.0
812	-9.7	12.7
813	-9.3	12.3
814	-8.9	11.9
815	-8.5	11.5
816	-8.1	11.1
817	-7.7	10.8
818	-7.4	10.4
819	-7.0	10.0
820	-6.6	9.6
821	-6.2	9.3
822	-5.8	8.9
823	-5.4	8.5
824	-5.0	8.1
825	-4.6	7.8
826	-4.2	7.4
827	-3.8	7.0
828	-3.4	6.6
829	-3.0	6.3

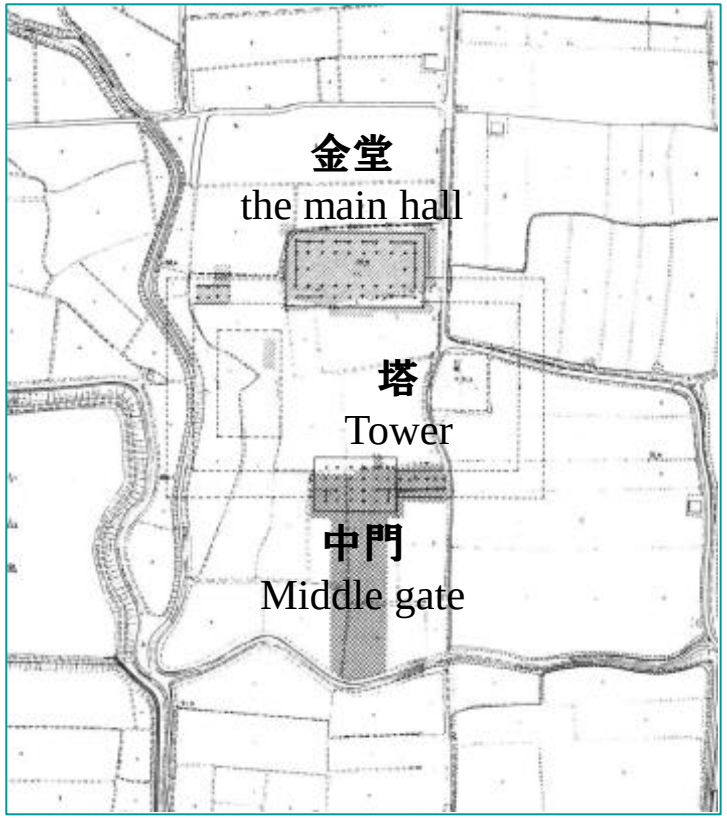
Note: Pole star is HR4893. Calculated on July 1 at 34.75° latitude. Positive Azimuth is west deviated and Negative is east. Also use the azimuth line diagram . This table is based on the results of verification of the orientation of Japanese remains that we know at this time.

7. Example of dating by the orientation of excavated remains

Emperor Monmu,大官大寺(Daikandaiji Temple)

- It was founded during the reign of Emperor Monmu (697-707).
- The offset of the central axis of the temple is about 22 min. and 13 sec. westward of true north .
- ➢ The Pole Star (HR4893) and the Liu xiu leading star give an estimated year of 704±7, which coincides with the time when Emperor Monmu's Daikandaiji Temple was built.
- ➢ This temple is located in Fujiwara-kyo, but the direction is almost the same as Heijo-kyo of the same period.

↑ Mount Kaguyama



【図と方位は奈文研「大官大寺第2次の調査」(1976)より】

↓ Palace of Asuka

Orientation of remains of Otsukyo-related ruins

According to Hiromichi Hayashi(2005)

① Otsukyou：85 min. eastward

② South shiga ten.：85 min. eastward

③ Hannokihara ruin：85 min. eastward

⇒Measured by Bigg Dipper 4th star

④ Soufuku Temple：

North ridge Mirokudo：8° eastward

Middle ridge Main hall：8° 40' to 9° e.

South ridge Main hall:：3° easetward

(⇒Corrected to 25 min. westward)

auditorium：2° 30' eastward

(⇒Corrected to 21 min. westward)

(Kyodo：80 min westward)

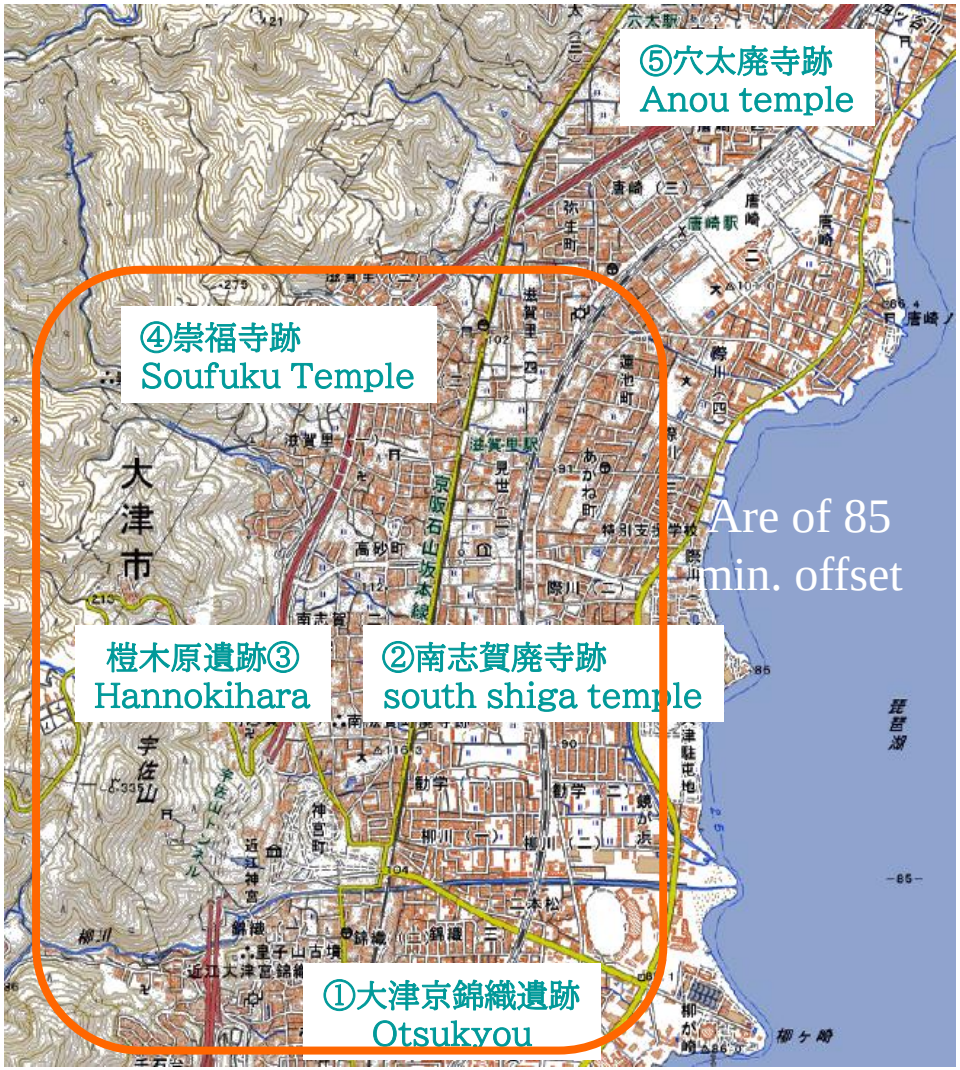
⑤ Anoutemple：

rebuilt cathedral/auditorium

：2° 30' min. eastward

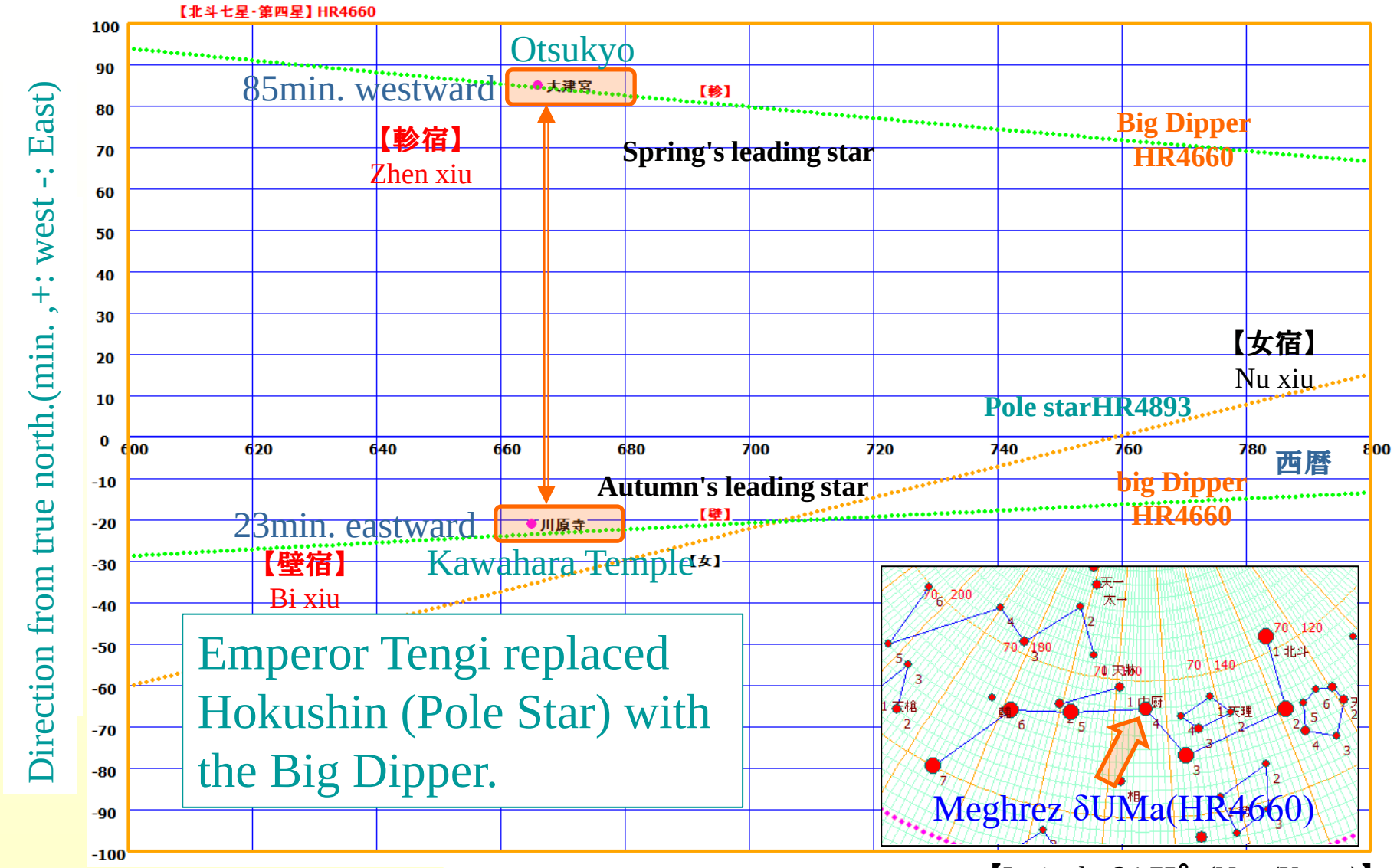
Main hall/Tower：(5min. weastward)

⇒If they were built at Otsukyou era, the direction should be around 23min. eastward. Re-measurement is required.



【Note：Corrected based pm 宮原健吾/宇野隆夫/臼井正「方位からみた大津宮と崇福寺」(2006)より。】

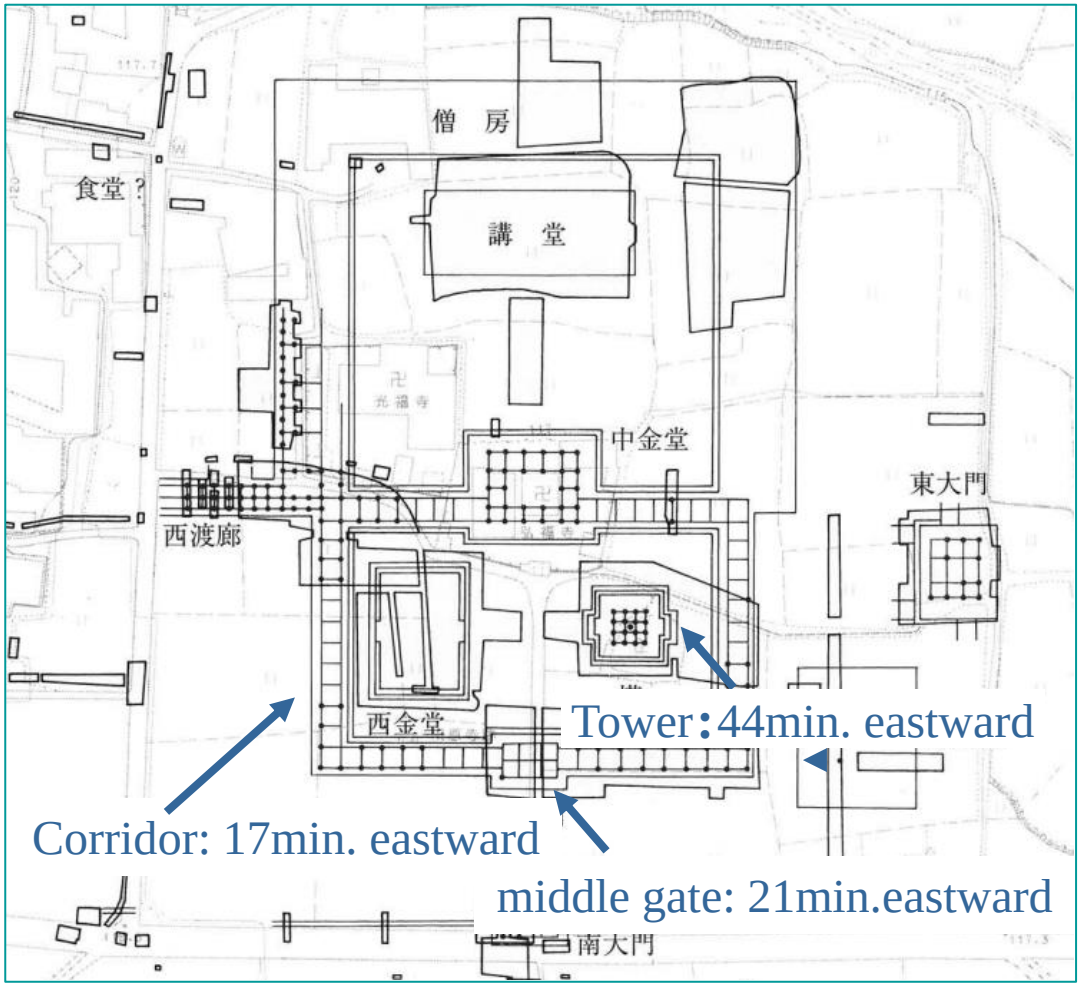
The direction of Otsukyo (measured by the Big Dipper 4th star (HR4660))



【Latitude：34.75° (Nara/Kyoto)】

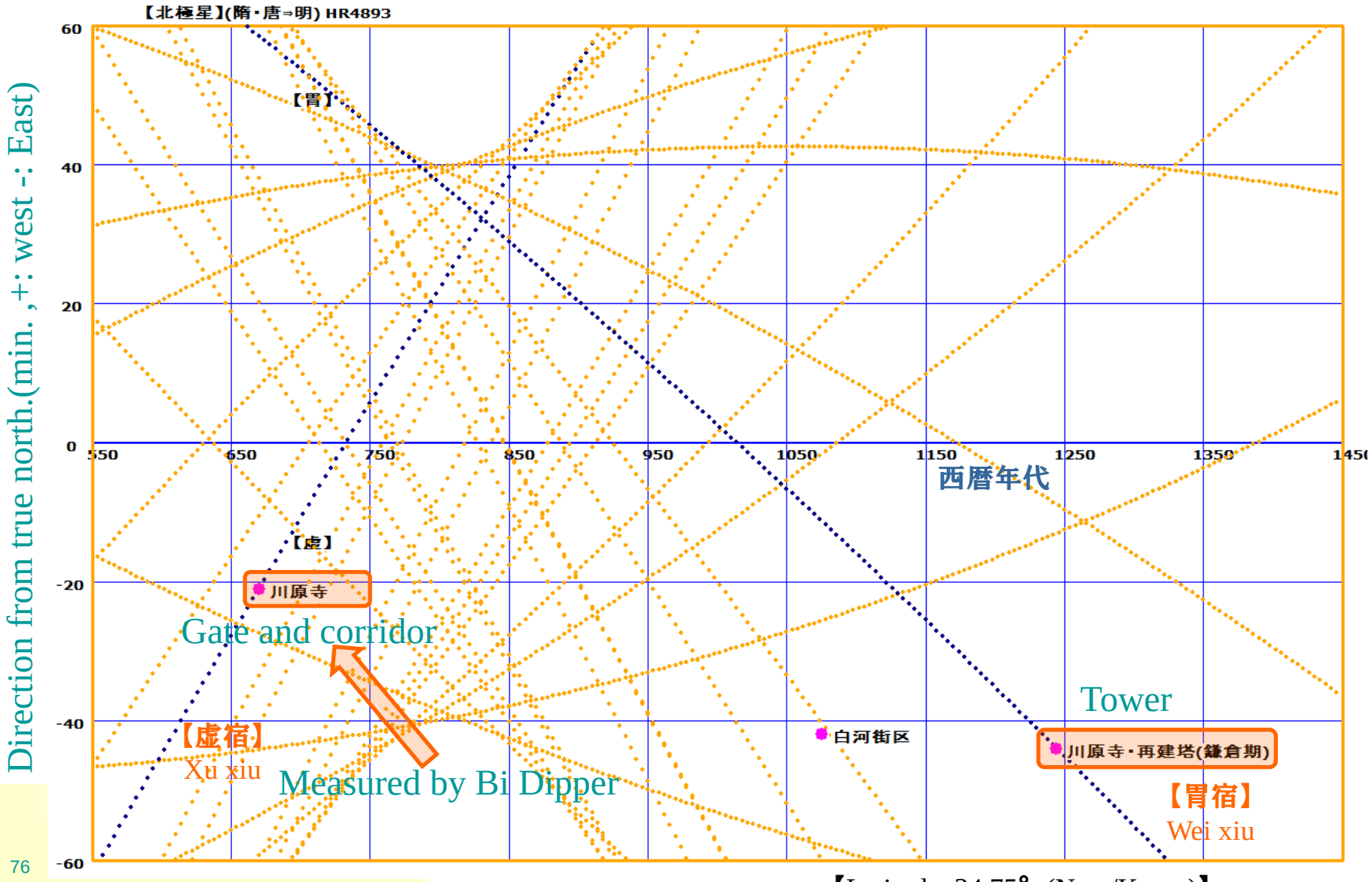
Azimuth of 川原寺(Kawahara Temple) in Asuka

- Temple built after the Asuka Itafutamiya fire (655) at the ruins of Kawahara Palace
- It was erected after the death of Emperor Saimei (661) to pray for his soul
- 667 Capital moved to Otsukyo
- In the second year of the reign of Emperor Tenmu (673), there is an article about copying Issaikyo at Kawara-dera Temple.
  - ➢ Gate；21min. eastward
  - ➢ Corridor:17min. eastward
  - ➢ Tower(Kamakura)：44min. eastward⇒1244±7



【「川原寺寺域北限の調査」奈良文化財研究所(2004)p.9より】
測定方位は，宮原健吾/宇野隆夫/臼井正「方位からみた大津宮と崇福寺」(2006)より。

Azimuth line by Pole star (HR4893) and direction of the ruins of Kawahara Temple



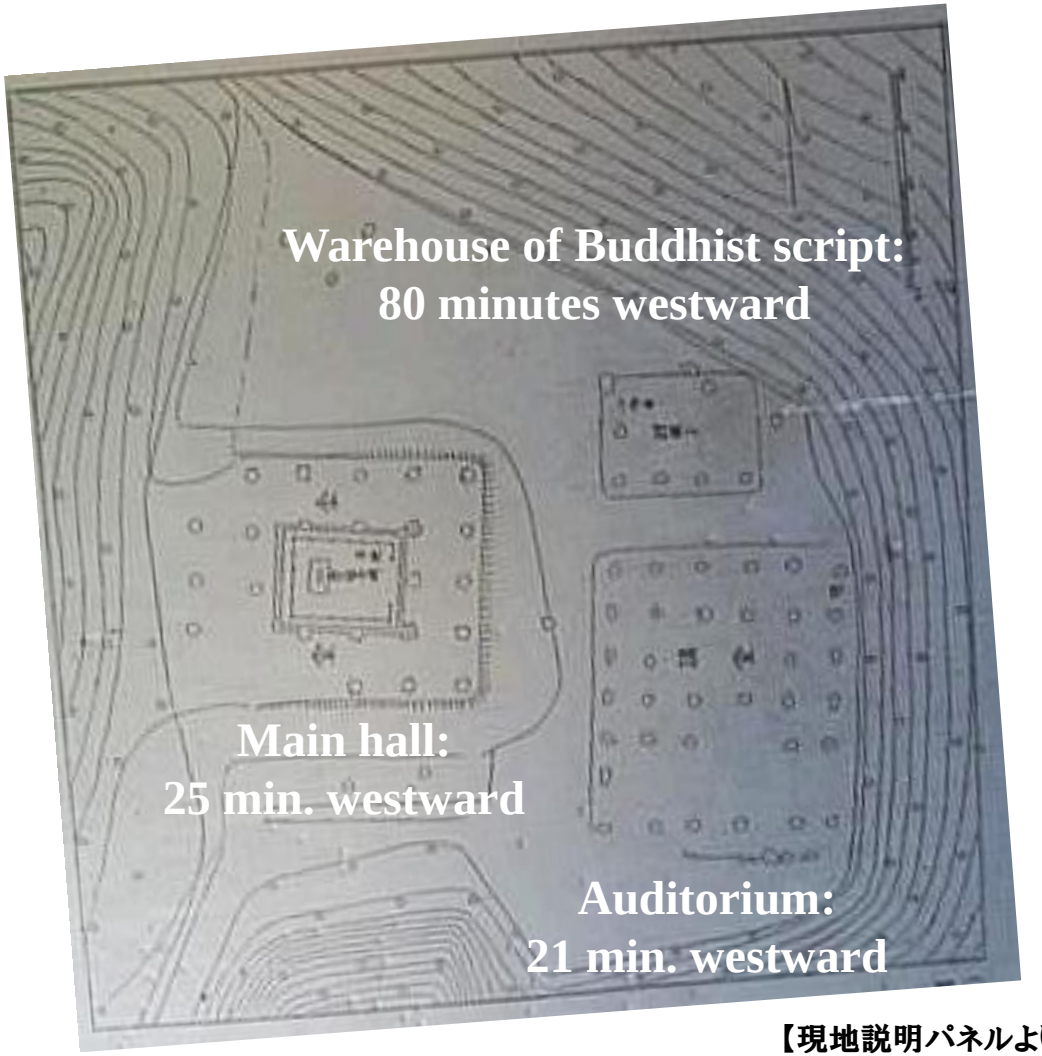
【Latitude：34.75° (Nara/Kyoto)】

Ruin of 崇福寺 (Soufukuji, South ridge)
⇒ 梵釈寺（Bonsyakuji）

- It is believed that the temple site on the south ridge of Sofuku-ji Temple in Otsu City may be Bonshaku-ji Temple (786) founded by Emperor Kanmu, but this has not been confirmed.

- Main hall：25 min. westward
  ⇒year 779±7
- Auditorium；21min. westward
  ⇒year 790±7
- Warehouse of Buddhist script：80 min. westward
  ⇒Otukyo period

- The central axis (average value) of the construction direction matches the age of Bonshakuji Temple.



【現地説明パネルより】
【測定方位は宮原健吾/宇野隆夫/臼井正「方位からみた大津宮と崇福寺」(2006)より】

8. Dating of the ancient straight road by its direction

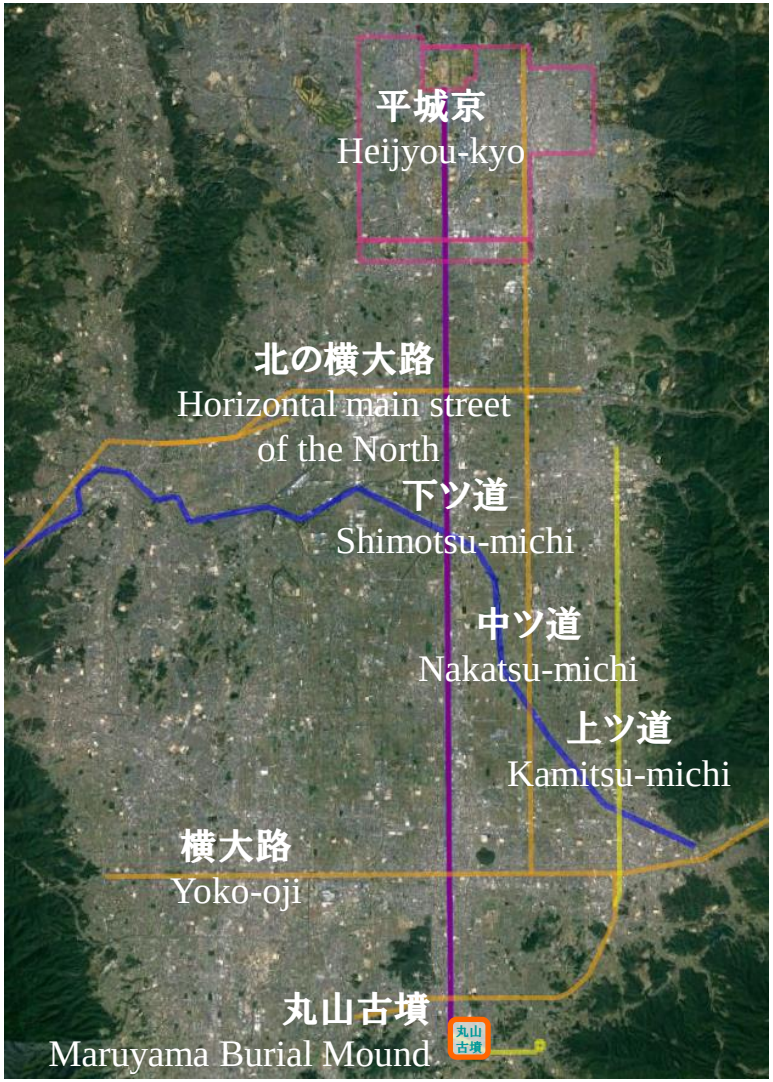
*The estimated age of the ancient road here is the date of construction of the true north-south straight road where remains remain, and does not deny the existence of the existing road before that.

The dating of ancient roads

- General methods for estimating the date of excavated remains
  - Strata overlap
  - Overlapping Remains
  - Date of excavated earthenware and roof tiles
- Why dating of road is so difficult
  - Very few relics have been found
  - Necessity to assume influx from other lands even if relics are excavated
  - Long-used roads may be repaired
- Even if pottery is excavated in one place on a road, there is a problem in using it for estimation of the entire road of several kilometers. Until now, estimates of the date of roads have been inferences based on circumstantial evidence based on documents, etc., with few excavation results. Therefore, there is no archaeological basis for the popular theory.
- **The direction of the road is the only physical evidence that can identify the date of the "entire road".** The estimation of the construction date based on the direction of the true north-south road is the first method of estimating the actual date based on scientific grounds.

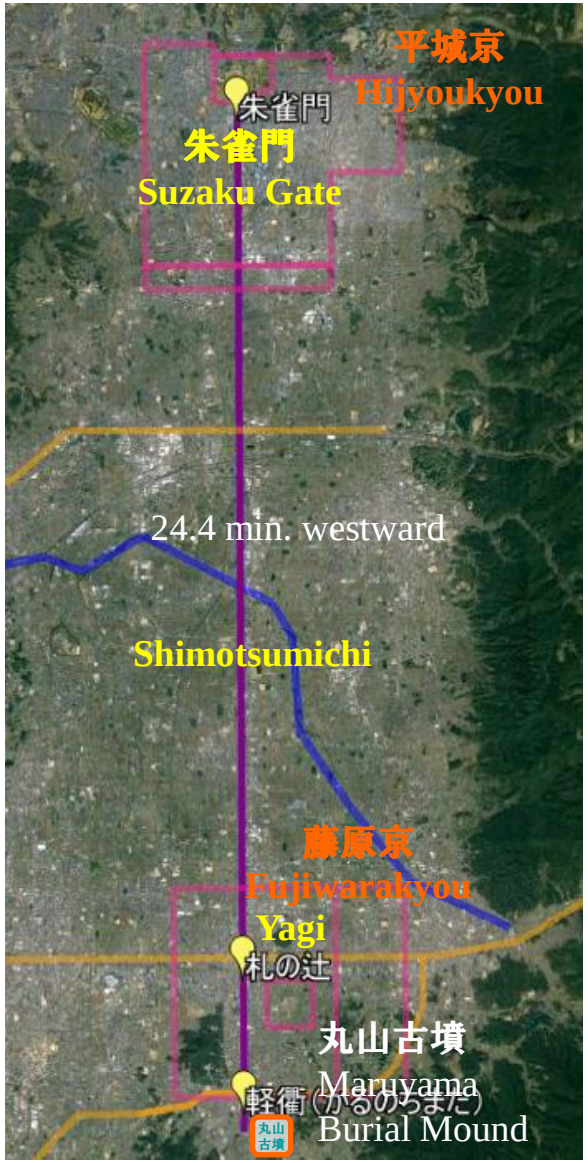
Dating of the three ancient roads in the Yamato Plain

- According to the established theory, the three ancient Yamato roads (Kamitsu-michi, Nakatsu-michi, and Shimotsu-michi) are considered to have been constructed at approximately the same time, based on the Shimotsu-michi, since the distance between them is the same.
- The Shimotsu-michi Route was built starting from the north of Maruyama Burial Mound (common theory).
- Dating of the road already announced.
  - ➢ Based on these popular theories, it is believed that the road was built during the reign of Emperor Suiko (biginning of the 7th century), and is said to be closely related to Maruyama Burial Mound.
  - ➢ The theory in the middle of the 7th century, which is based mainly on the true north orientation (after Itabuki no Miya).



Direction of the Shimotsumichi

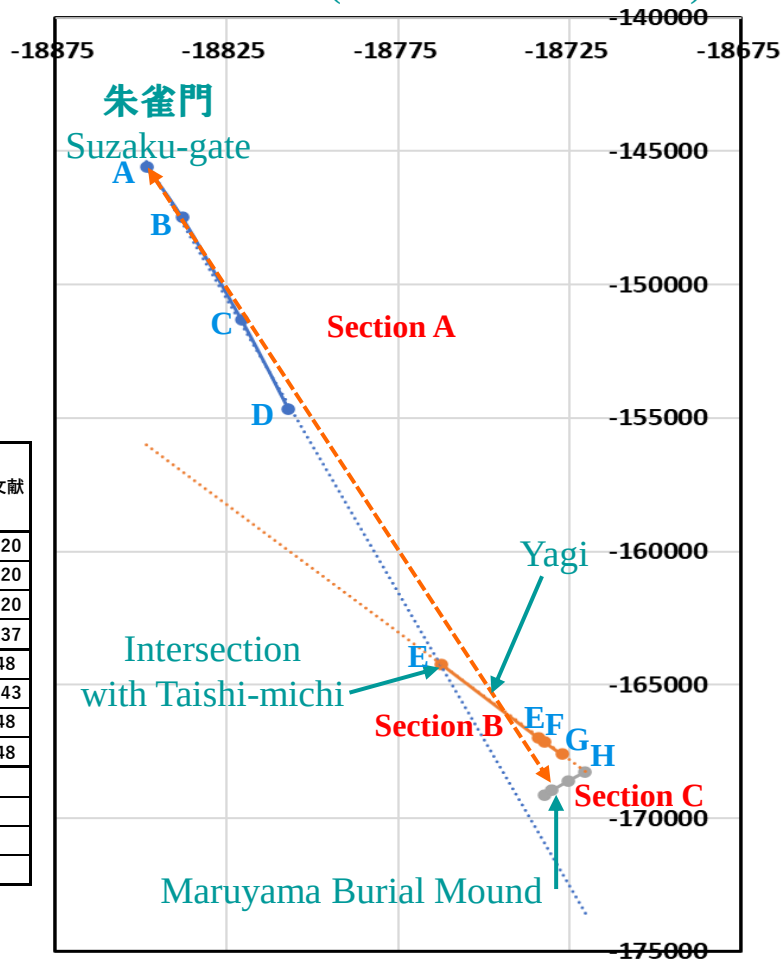
- Shimotsu-michi is an ancient straight road that became the basis of Fujiwara-kyo and Heijo-kyo.
- The Direction of Shimotsu-michi is said to be 24.4 minutes westward on average, connecting the Yagi, Kashihara City site and the Suzaku gate.
- If you calculate the direction by road (latitude and longitude),
  - Yagi ⇒ Suzaku Gate：24.2min.
  - Karunochimata ⇒ Gate：25.4min.
  - Mruyama Mound ⇒ Gate：24.6min.
- It is believed that they were built starting from the Maruyama Burial Mound in the same direction.



Data of the Shimotsumichi

- The offset of the C section averages the start and end points, making it difficult to find the deflection peculiar to the B and C sections.

Shimotsumichi (Center of the side ditch)



[world geodetic system]

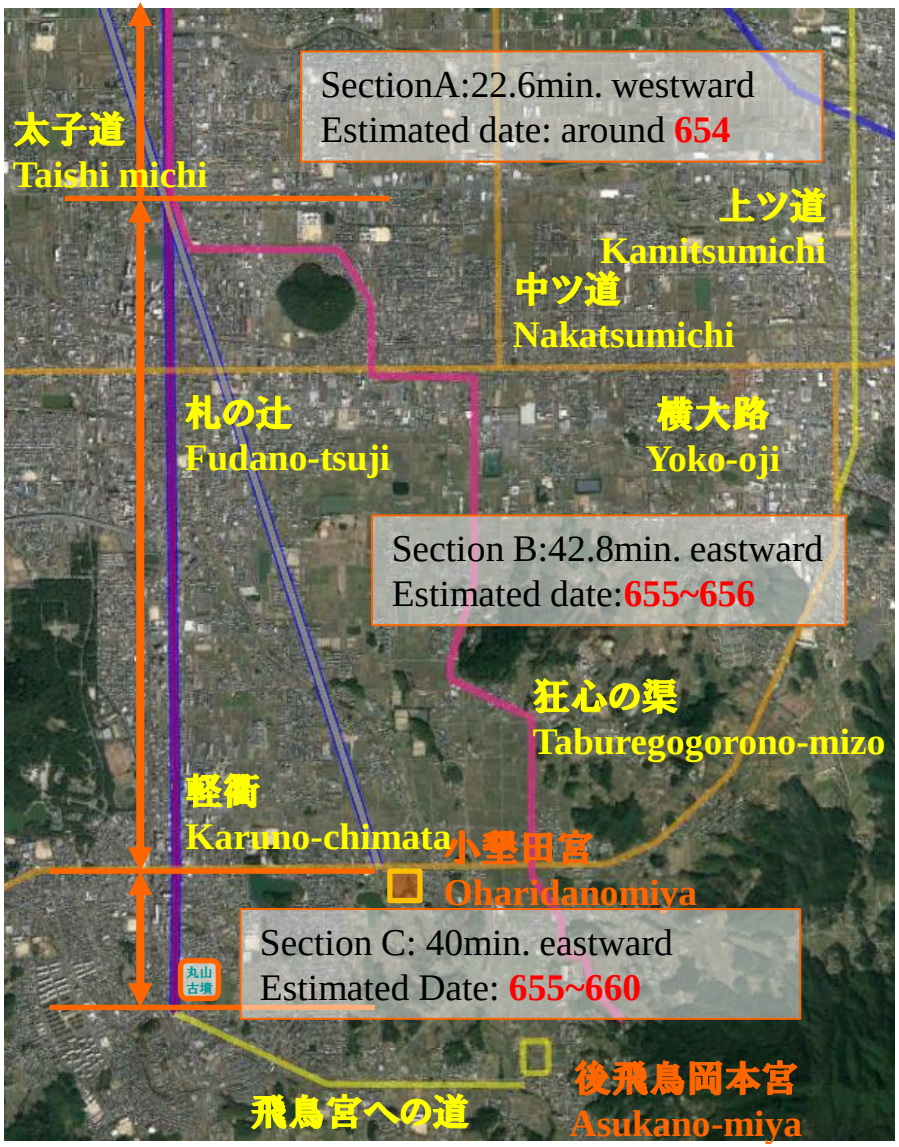
Data of the Shimotsumichi

Exca-vation data

	発掘場所	発掘年次	世界測地系				参照文献
			Y座標			X座標	
			東側溝心	西側溝心	中心		
A	朱雀門		-18836.98	-18859.78	-18848.38	-145601.50	[12]p.20
B	朱雀大路(五条-六条間)		-18826.30	-18849.71	-18838.00	-147486.99	[12]p.20
C	稗田遺跡		-18808.56	-18832.86	-18820.71	-151328.51	[12]p.20
D	八条遺跡		-18794.30		-18807.05	-154670.00	[21]p.37
E	藤原京右京四条五坊	橿教委1999-5次		-18775.39	-18762.64	-164223.45	[5] p.48
F	藤原京右京七条四坊	藤原京第58-5次(1988)	-18721.49		-18734.24	-166974.38	[13]p.43
G	藤原京右京八条五坊	橿教委1995-7次		-18745.14	-18732.39	-167137.37	[5] p.48
H	藤原京右京十条五坊	橿教委2016-8次		-18740.00	-18727.25	-167599.00	[5] p.48
C区	軽衢				-18720.63	-168248.86	筆者
C区	道路二又				-18725.45	-168585.10	筆者
C区	丸山古墳削減点				-18730.41	-168952.85	筆者
C区	飛鳥入口				-18732.34	-169138.35	筆者

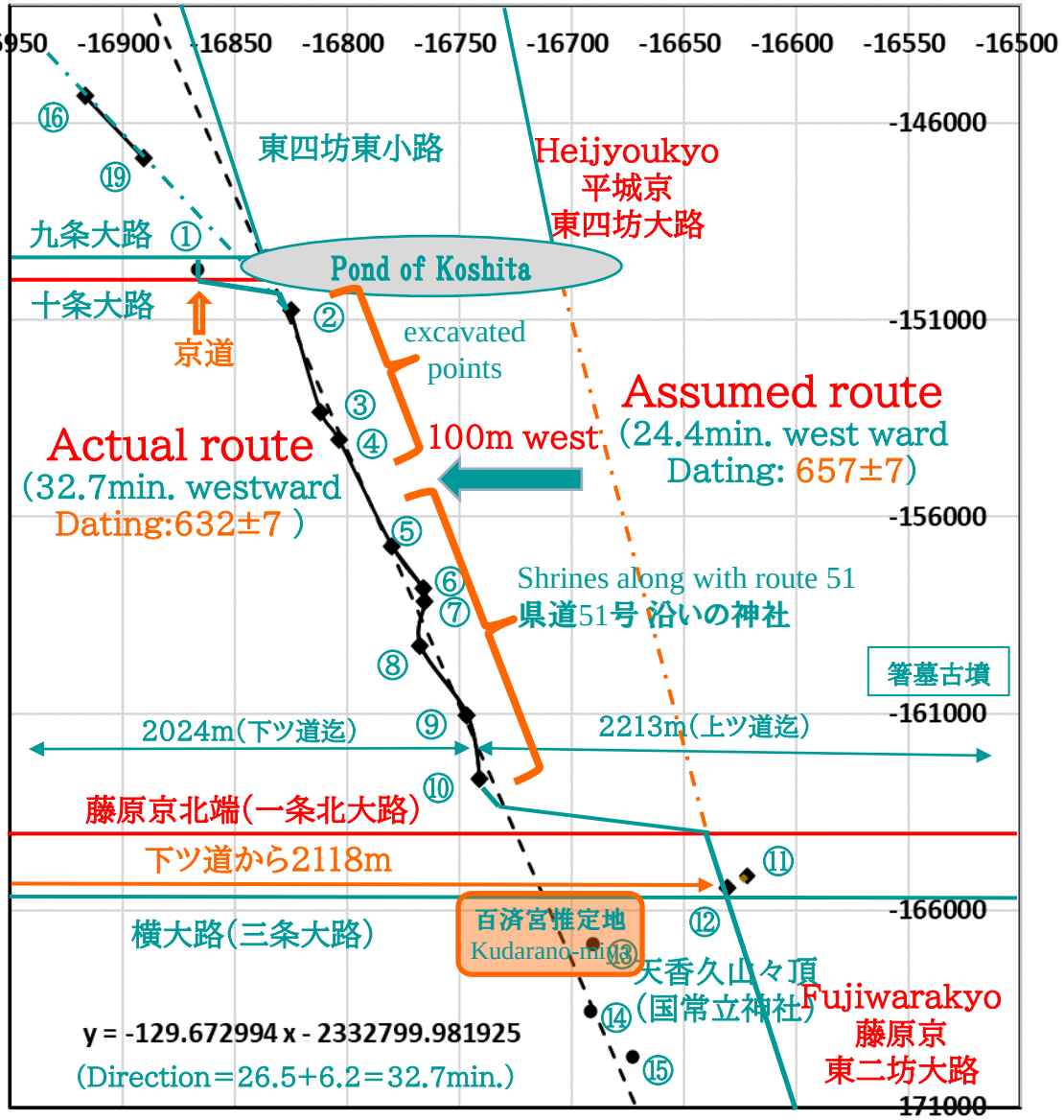
Consistency of the construction date of the three sections with the Nihonshoki (Chronicles of Japan)

- Section A: Road to North
  - 白雉四年(653)脩治処処大道
- Section B: Road to Oharidano-miya
  - 斉明天皇元年(655)
    小墾田造起宮闕、擬将瓦覆。
    又於深山広谷。擬造宮殿之材。
    朽爛者多。遂止弗作。
- Section C: Road to Asukano-miya
  - 斉明天皇二年(656)
    遂起宮室。号曰後飛鳥岡本宮。
  - 自香山西至石上山。狂心渠。
- **Sections B and C are clearly constructed in the Saimei period (655-661) from their orientation.**



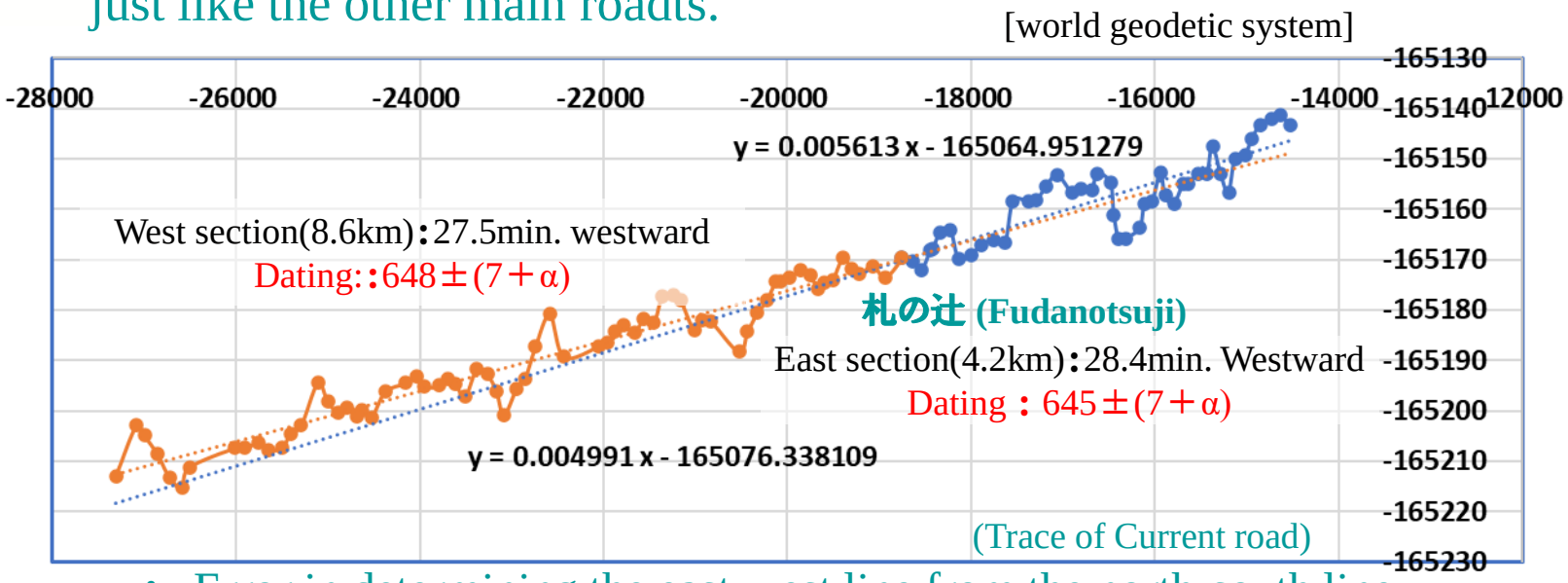
Dating of Nakatsumichi by its direction

- Nakatsumichi's actual route was 100m west of the asumed route. ⇒ Unrelated to FujiwaraKyo's jobo.。
- The equally spaced road was not Nakatsumichi, but Jobo of Fujiwarakyo.
  - ➢ The direction is 32.7 min. westward, and 8.3 min. westward of Shimotsumichi.
  - ➢ The estimated date is 632±7 year. ⇒Overlaps with Emperor Jomei's Kudara Palace(639)
  - ➢ The three ancient roads was not evenly spaced, nor was it the same period.

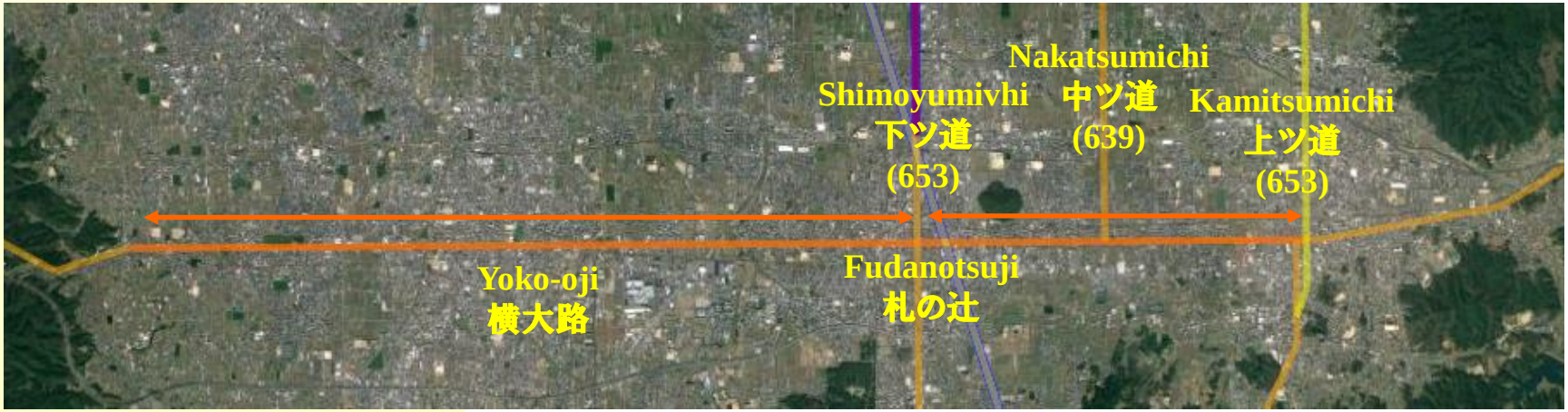


Dating of Yoko-oji (Horizontal main street) by its direction

- Based on its Direction, Yoko-oji is thought to have been built in 653, just like the other main roadts.

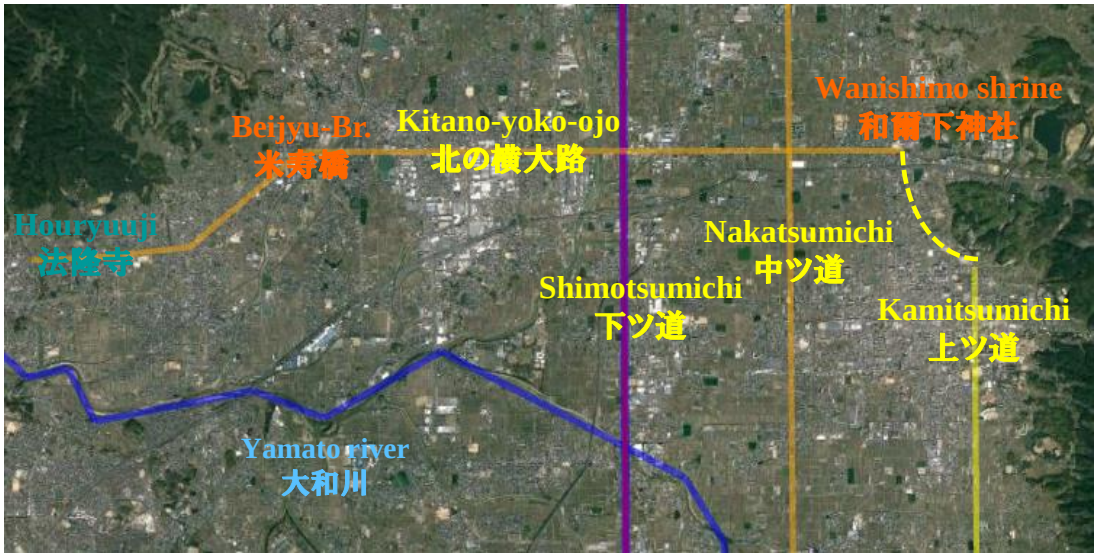


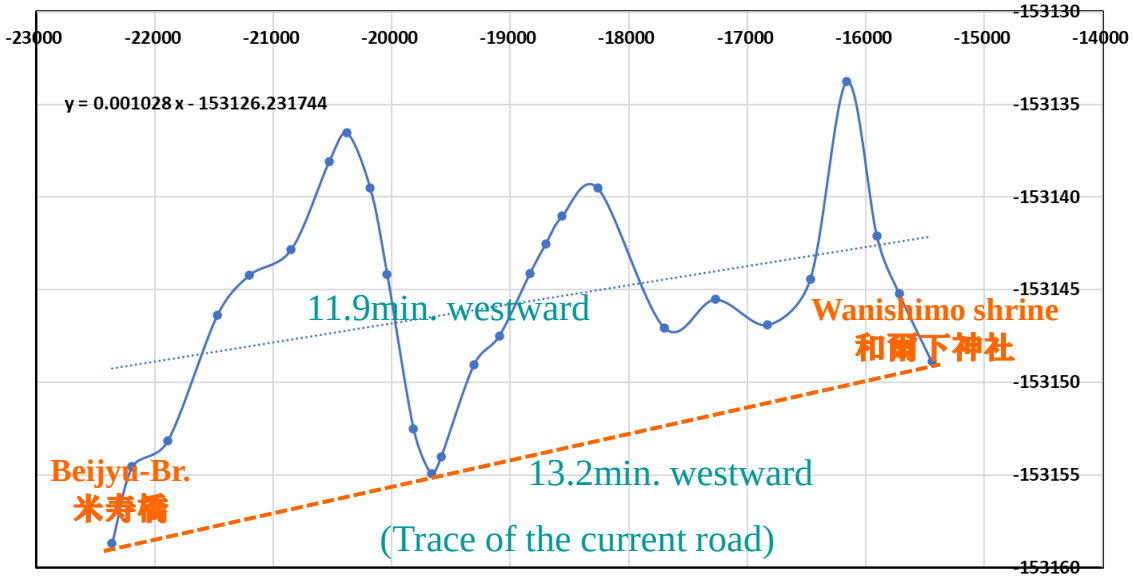
α： Error in determining the east-west line from the north-south line。



Dating of Kitano-yoko-oji (Horizontal main street of north) by its direction

- Direction:
  - Beijyu Br. to Wani Shrine :13.2 min. westward
  - Direction by the road :11.9 min. westward
- Dating(around AD730)
  13.2min.:AD728±(7+α)
  11.9min.:AD731±(7+α)
- With the construction of Naniwa Palace during the last years of Emperor Shomu (around 726-732), a straight east-west road was redeveloped.
- The straight east-west road, which was developed at the same time as the Shimotsumichi was repaired.

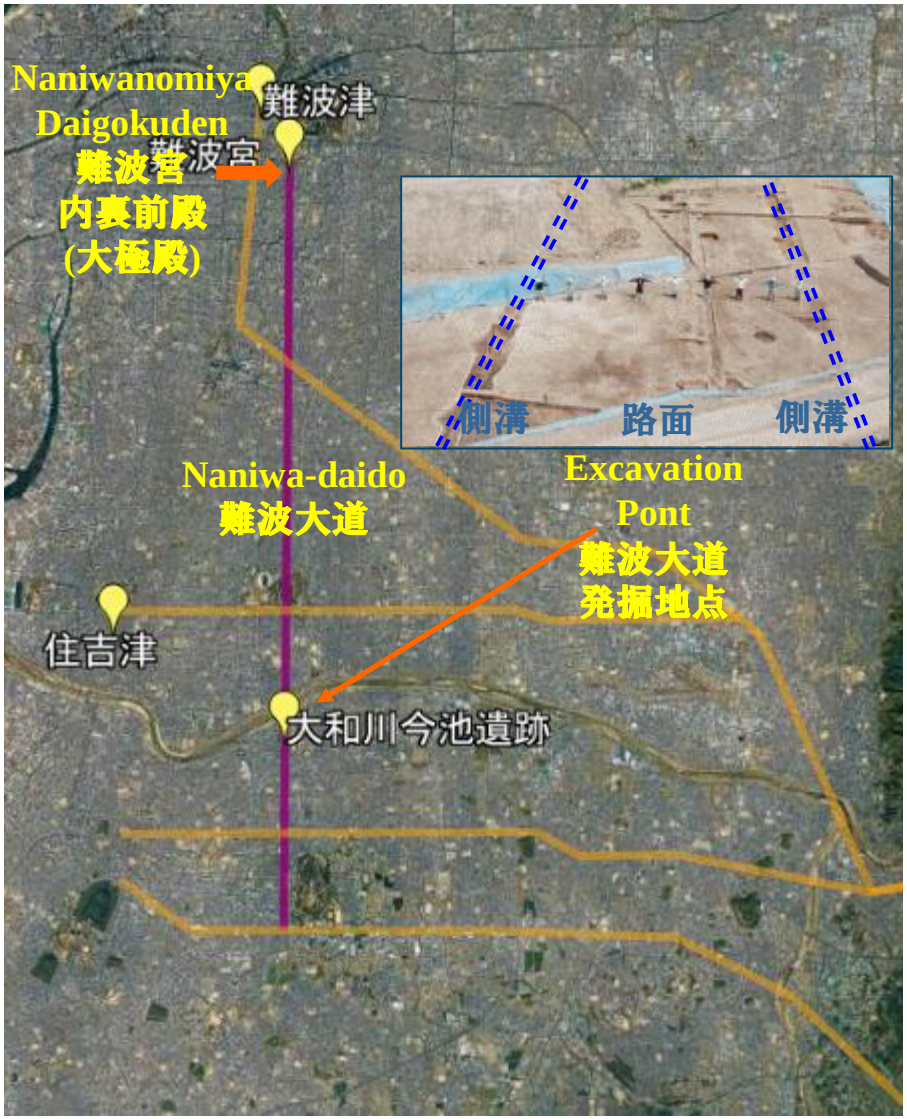




[world geodetic system]

Dating of Naniwa-daido by its direction

- Naniwa-daido starts from Naniwa Palace and continues south. Its direction coincides with the 26.8 min east direction in 653, and it was built at the same time as Shimotsumichi.
- The direction measurement is 9.8 km from the Naniwa Palace to the Yamato River excavation point.
  - 26.2 min. eastward
  - Dating: AD 648 to 654
- It is also consistent with the dating (from the middle of the 7th century) based on the excavation (overlapping of earthenware and strata).



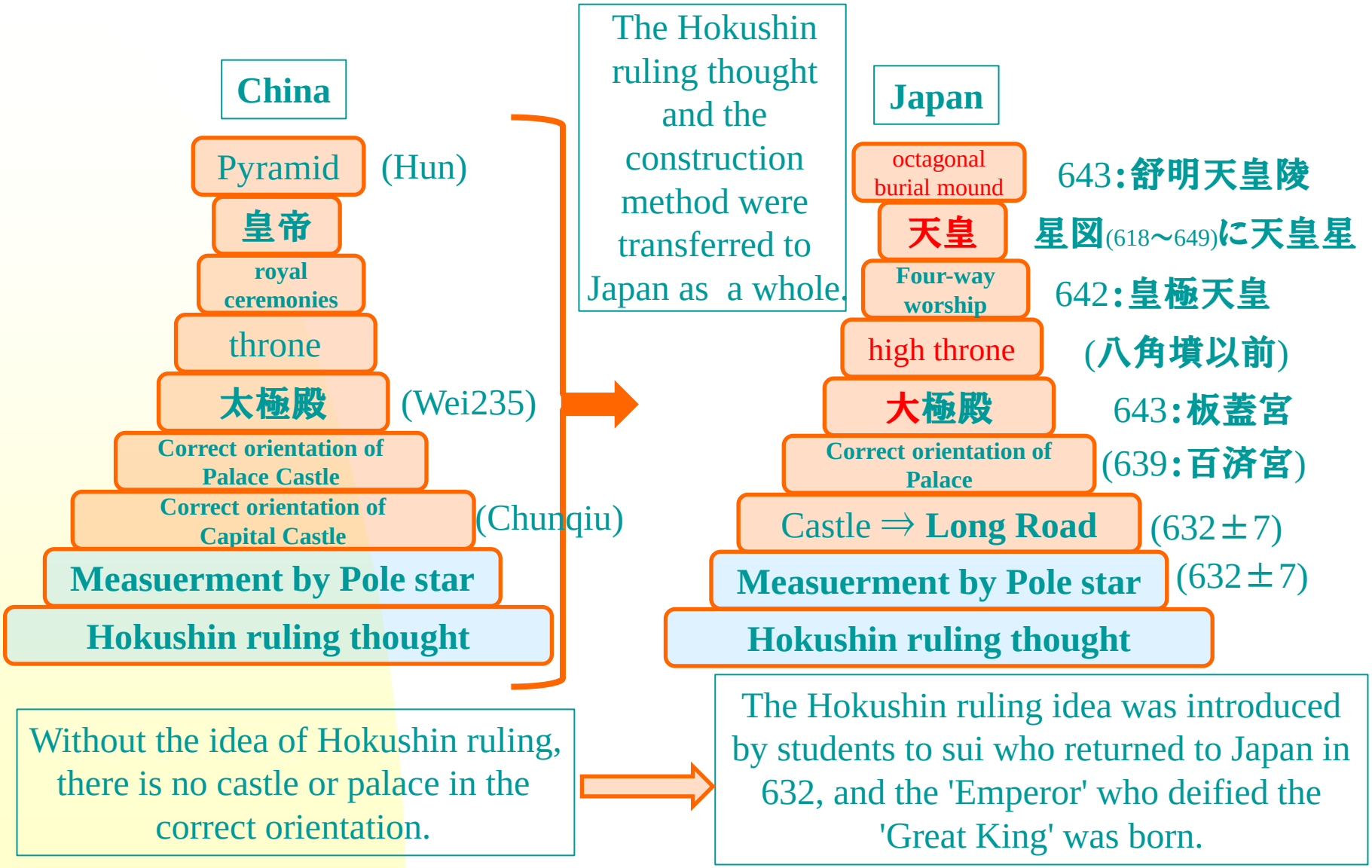
(発掘現場の写真は大阪府HPより)

9. The introduction of Hokushin ruling thought to Japan

The true north orientation of the palace signifies the introduction of Hokushin ruling thought.

- In China, from the Chunqiu period to the Middle Ages, the construction of the capital's castle used the direction measurement method by the Pole Star.
- The stage (castle, palace, Taigokuden) measured by the Pole Star is the embodiment of the existence of the Heavenly Emperor (Hokushin/Pole Star).
- By performing dynastic ceremonies on this stage, the emperor legitimizes the rule that received the ``Destiny of the Heavenly Emperor" (Hokushin ruling thought).This is the reason why the enthronement ceremony is held at the Daigokuden in Japan.
- The correct orientation of palaces in Japan also means the introduction of the Hokushin ruling idea, not landscape maintenance.
  - The correct orientation of palaces ⇒Daigokuden⇒coronation ceremony⇒The "Tnno" was born

The Hokushin ruling idea of China was transmitted to Japan as a whole



詳細は、「古代の正方位測量法(第三版)」PDF版(2022/04/01)を参照。

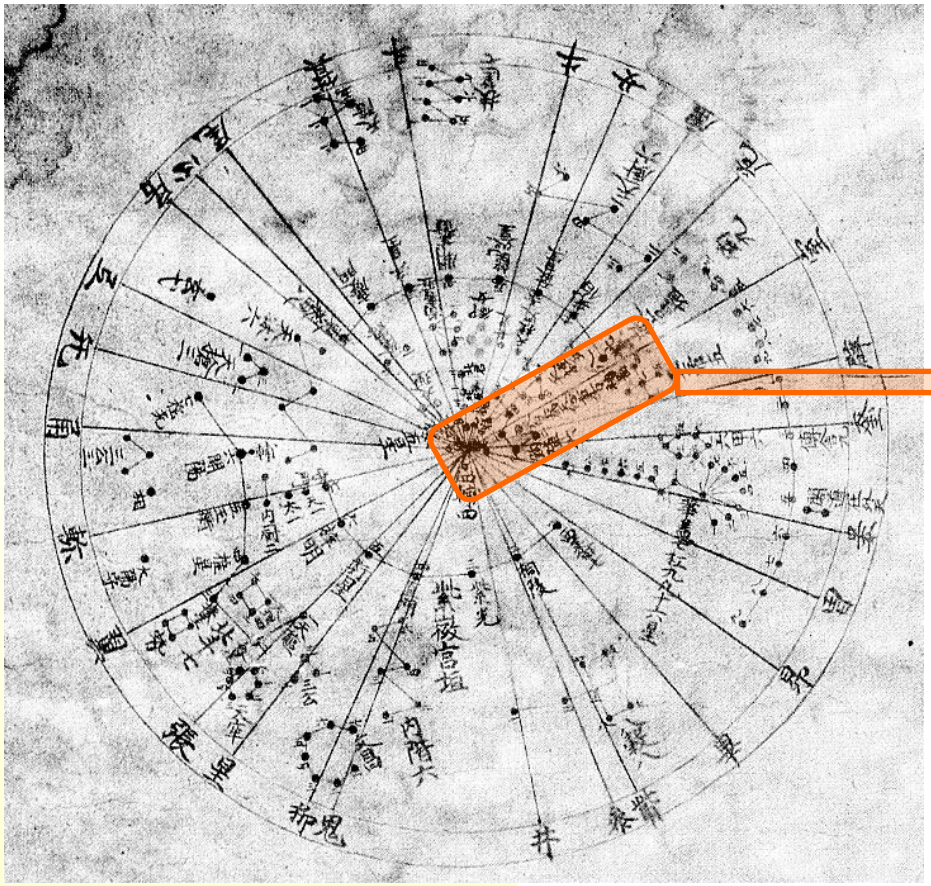
When did the idea of the Hokushin rule reach Japan?

- Correctly oriented palaces and roads are measured by Pole star,
  - It is presumed that the ideas and basic technology of the Hokushin ruling thought were introduced between Asuka Okamoto Palace(630) and Kudara Palace(640).
  - A star chart with the 'Emperor' star was also introduced.

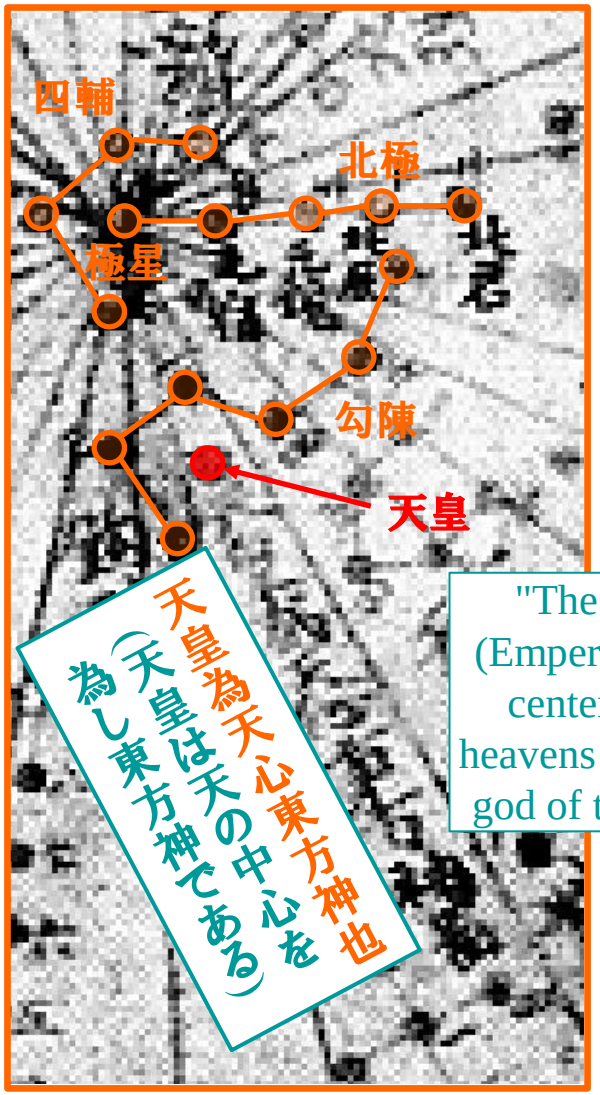
	推古	舒明		皇極	孝徳	斉明	天智	天武	持統	
	小墾田宮 (603)	岡本宮 (630)	百済宮 (640)	板蓋宮 (643)	難波宮 (652)	後岡本宮 (656)	大津宮 (666)	浄御原宮 (672)		藤原京 (694)
Octagonal burial mound	X	–	○	–	X (round)	○	○	○	○	
Palace of Pole star	X	–	(○) (Assume)	○ (書紀)	○ (内裏前殿)	○ (SB7910)	?	○ (SB7910)		○
True north oriented Palace	(X)	X (20°西偏)	(○) (Assume)	○	○	○	85min. West	○		○
True north oriented Road			○ (Nakatsu)		○ (Naniwa)	○ (Shimotsu)				Jyou-bou road
Measured by Pole Star	(X)	X	○	○ (Assume)	○	○	Big Dipper	○		○

詳細は、「古代の正方位測量法(第三版)」PDF版(2022/04/01)を参照。

The etymology of『天皇』(Emperor) may be from『格子月進図』(star chart for moon)



【別冊 太陽 No.73(1991) p.38より】



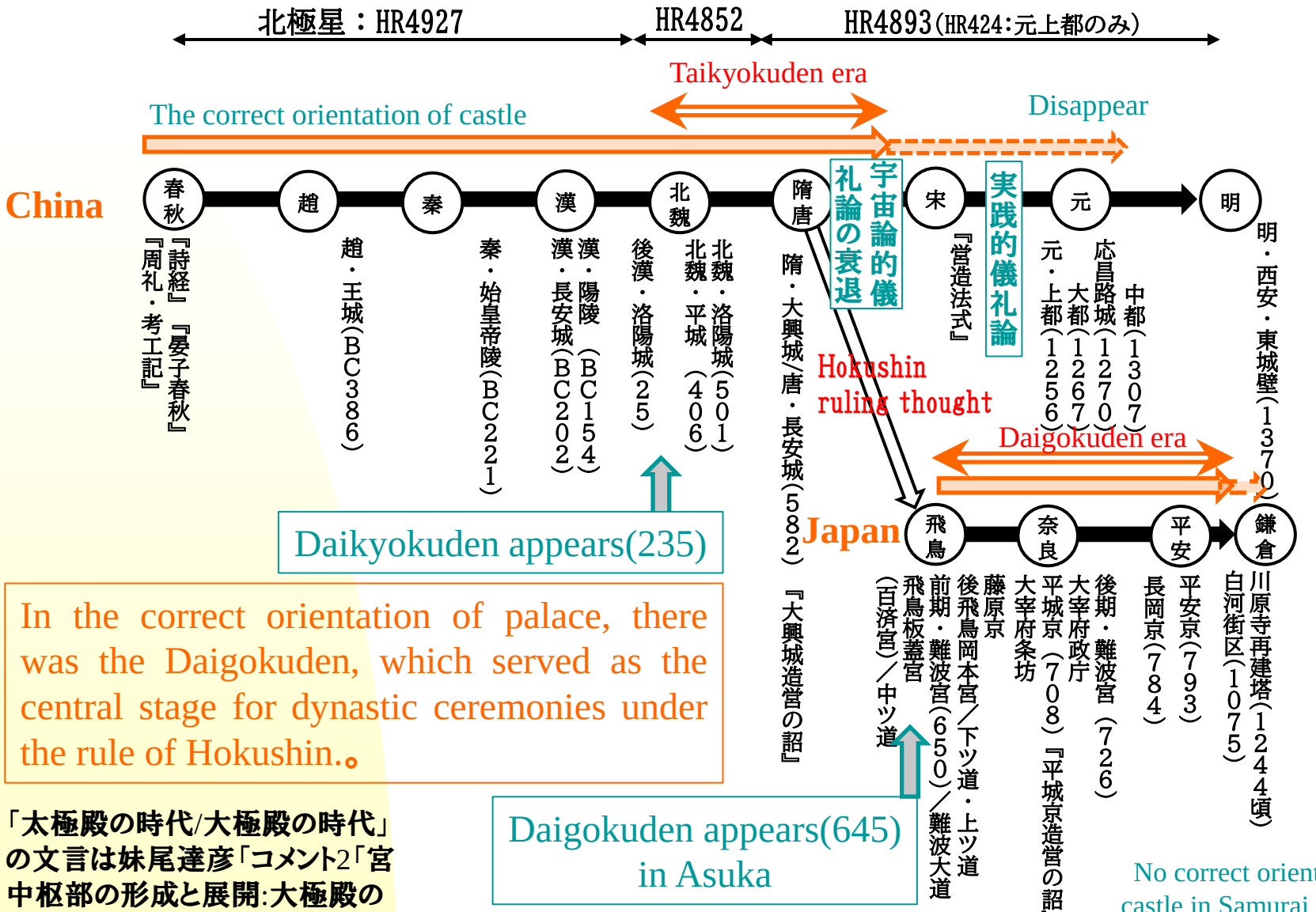
"The Tenno (Emperor) is the center of the heavens and is the god of the East."

Tenno-Tai-tei (**天皇大帝**) is in the journal of the book of Jin, but this book was not yet completed at the time of Emperor Jomei.

China **皇帝** ⇒ Japan **天皇**

10. Summary

The Meaning of the Capital Castle and Palace in the Correct Orientation



「太極殿の時代/大極殿の時代」の文言は妹尾達彦「コメント2「宮中枢部の形成と展開:大極殿の成立をめぐって」」(2009)より

詳細は、「古代の正方位測量法(第三版)」PDF版(2022/04/01)を参照。

end

How True North Was Measured by the Pole star in Ancient China